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CARGO FLOWS AND FACILITY REQUIREMENTS AT THE NEW MONTREAL INTERNATIONAL AIRPORT

a report to

OFFICE DE PLANIFICATION ET DE DÉVELOPPEMENT DU QUÉBEC

PROJECT 2-116

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ET DE DEVELOPPEMENT DU QUEBEC

Project 2-116

February 1973

prepared by

MANALYTICS, INC.

San Francisco

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I. SUMMARY

Purpose and Scope

The Quebec Government has a firm intention to participate in the planning and development of the new international airport at Sainte-Scholastique as well as plan the land use and the economic activities immediately surrounding the airport. In addition to the obvious impact on passenger traffic, the new airport will become a major North American gateway for air cargo. A modern, efficient and low-cost air cargo terminal at the new airport could significantly increase the amount of air cargo moving through Montreal. The development of Montreal as a major transportation center will attract transportation-sensitive industries which will, in turn, enhance the economic development of the region.

In order to assist the Government of Quebec in their regional planning as it pertains to the development of the new airport, Manalytics, Inc. of San Francisco undertook a three-part study in October of 1971. The three parts were concerned with defining the air cargo markets, an analysis of the costs of an air cargo terminal and an analysis of the potential of a distribution center located in the area for air and surface freight. Additional studies will be undertaken by the Quebec Government to investigate other aspects of establishing Montreal as a major transportation center. These future studies will be concerned with all modes of transportation and the resulting economic development of the area.

Our analysis of the air cargo market was divided into three major steps. We first forecast total cargo movements (surface plus air), estimated the proportion of the total cargo movements that will move by air and, finally, we estimated Montreal's share of the total air cargo market under a variety of assumptions. We analyzed three different services which account for the majority of the air cargo that will move through Montreal. These services are Canadian domestic, Canadian/U.S. transborder and North America/Europe.

Our analysis of the costs of the air cargo terminal consisted of reviewing functions, facilities, procedures and costs of air cargo terminals in general in order to compare, in a theoretical sense, the proposed Montreal terminal with other terminals, principally New York. We then developed more detailed estimates of the Montreal facility requirements and costs.

The principal functions of an air cargo terminal are to receive and release air cargo to/from land transport (usually trucks) and to load and unload the cargo to/from aircraft. As such, the storage capability of an air cargo terminal is small -- sufficient only to store the cargo for a day or two.

An air cargo terminal can be structured as a common-user terminal or as a series of proprietary terminals or some combination of the two. A common-user terminal, sometimes referred to as a centralized terminal or a joint terminal, is a terminal where a single terminal operator serves all airlines. A proprietary terminal serves a single airline (or a limited group of airlines) and the terminal operator is usually the airline itself. A possible combination of common-user and proprietary terminals is to have a common-user freighter dock and proprietary terminals for sorting, storing, receiving, etc. Common-user terminals have cost advantages over proprietary terminals since the larger scale of operation allows more efficient utilization of men and equipment. Proprietary terminals are favored by airlines because they have direct control over the cargo and maintain the airline's image. Common-user, proprietary and combination air cargo terminals were analyzed.

The analysis of a distribution center includes defining potential users in terms of regions, commodities and volume. Additionally, distribution center services are described, the market potential estimated, and costs analyzed.

The major purpose of a distribution center is to perform the warehouse function -- to store cargo until required. Warehouses are used as a buffer between production and consumption schedules and, just as importantly, allow a producer to store the cargo at his facility until he has enough cargo to ensure minimum transportation costs. The warehouse at the receiving end distributes the cargo as required. Many companies are large enough to have proprietary warehouses of sufficient size to experience minimum or near minimum warehouse costs. Many companies with medium or small warehouses in a given market area are at a competitive disadvantage because of high warehouse and transportation costs. These companies are potential customers for a distribution company. The distribution company is a common-user warehouse company that provides additional services. The most important additional services are order picking (making up a shipment of mixed commodities) and delivery services. If the distribution company has enough customers, it can provide warehousing, order picking and delivery services at costs lower than the customers would realize if they attempted to operate their own proprietary warehouse.

The inventory in a distribution center will turn over between 3 and 30 times per year, illustrating the warehouse function. The cargo in an air cargo terminal will turn over hundreds of times annually. Therefore, a distribution center (company) is functionally different from an air cargo terminal.

Conclusions

As a result of our analysis, we conclude that:

1) While air cargo has been growing at rates as high as 28 per cent per year in the past, air cargo will grow at rates between 8 and 20 per cent per year in the future, depending on the service considered.

2) The estimate of tonnage moving through the new Montreal airport in 1975 will range from a low of 158,000 to a high of 372,000 short tons, assuming that Toronto does not become a major international air center. The expected value will be about 185,000 tons, if the Quebec Government is passive, and 284,000 tons if the Quebec Government mounts an aggressive marketing campaign. The 284,000-ton estimate is more than three times Montreal's 1970 tonnage. The tonnage loaded to and from aircraft will be slightly higher because of transshipments.

3) If Toronto becomes a major international airport, about 143,000 tons will move through the Montreal airport in 1975 if the Quebec Government is passive. An aggressive marketing campaign will increase the tonnage movement to about 192,000 tons.

4) The tonnage moving through the new Montreal airport in 1985 will range from 334,000 to 1,123,000 short tons with the most likely volume being about 710,000 tons, assuming that the Quebec Government mounts an aggressive marketing campaign and that Toronto does not become a major international air terminal.

5) The minimum throughput for an efficient common-user cargo terminal is about 80,000 tons per year.

6) The annual reduction in air transportation costs realized by routing cargo through the new Montreal airport instead of competing air centers will be between $2,000,000 and $4,000,000 annually if Toronto does not become a major air center for European air cargo and between $1,000,000 and $3,000,000 annually if Toronto does become a major air center.

7) The proposed terminal will have marginal spacing between the truck loading/unloading positons. Extreme care must be taken in the detailed building plan to ensure cargo can move efficiently to and from the truck loading/unloading positions.

8) The terminal should use finger piers for loading and unloading freighter aircraft. Three such piers will be required if the tonnage moving through the terminals reaches our 1975 estimate of 284,000 tons.

9) The terminal should be mechanized (not automated) and a common-user operator will require a single cargo building 600 feet long and 3 finger piers will be required for a movement of 284,000 tons, assuming

that the current design of 250-feet-wide cargo buildings is maintained, and assuming that the number of truck positions is adequate. Eight airlines operating proprietary terminals will require the equivalent of a single building 800 feet long and 8 loading modules.

10) The cargo-handling cost at a common-user terminal in Montreal will be about $27 per ton (including profit) at the estimated 1975 market of 284,000 tons. The handling costs at eight proprietary terminals and loading docks with the same total throughput will be about $38 per ton. The cargo-handling costs at eight proprietary terminals and common-user loading dock will be about $32 per ton.

11) The 1975 market for a distribution center located in Montreal could be as high as 271,000 tons but 100,000 to 150,000 is a more reasonable expectation.

12) A distribution center with a throughput of 100,000 to 150,000 tons per year would have an area of about 200,000 square feet and the costs will be between $24 and $26 per ton (including profit).

13) A distribution company should operate its own fleet of local delivery trucks. The distribution company, through better route planning, could experience delivery costs at least $3.00 per ton lower than a shipper who operates his own warehouse.

Recommendations

We recommend that the Quebec Government:

1) Develop an aggressive marketing campaign in cooperation with foreign and domestic airlines aimed at capturing European air cargo to and from the Great Lakes region of the U.S.

2) Work with airlines that will be using the cargo terminal and gain approval for a common-user terminal. If a common-user terminal is not possible, work toward a common-user freighter dock.

3) Review and analyze the terminal plan with potential common-user operators, paying particular attention to the number of truck loading/unloading positions.

4) Work jointly with RCMP and Provincial Police to establish the security of the terminal.

5) Perform a detailed market survey of the potential of a distribution center. The survey should concentrate on potential customers, their commodities and their requirements.

6) Investigate alternative sites for a distribution center and determine the economic impact of various sites on the potential customers.

II. TRADE FLOWS

Air cargo has been growing at rates exceeding 20 per cent per year while overall trade has been growing at about 5 per cent per year. It is our position that most of the growth in air cargo comes from "stealing" cargo from other modes of transportation rather than a high growth rate of the air cargo itself. If air cargo is to continue to grow at rates higher than the rate for the total trade, it must continue to "steal" cargo from surface modes. Therefore, any forecast of air cargo movements must include a forecast of the total trade.

We have divided the discussion of our analysis of air cargo that will move through the new Montreal airport into the following sections:

Services and nodes

Cargo data base

Total market forecast

Air cargo forecast

Summary

The first section defines the services and the nodes that are considered in this study. The second section defines the cargo data base -- that is, the total cargo (surface plus air) moving in the various services for a base year. The total cargo flow forecast is discussed in the third section, divided into surface and air modes in the fourth section and, finally, Montreal's share of the air cargo is discussed in the fifth section. The last section of this chapter summarizes our findings on the air cargo flows through the new Montreal airport. The sensitivity of market share to costs, frequency, etc. and the economic feasibility of an air freight terminal are interrelated. A section discussing these subjects has been included in the following chapter.

Services and Nodes

We have analyzed four basic services or trades:

Canada/Europe
United States/Europe
Canada/United States
Canadian domestic

Montreal will be a major terminal for the Canadian services listed above. The U.S./Europe service was included in the analysis because the cargo originating or terminating in the Great Lakes region of the United States could use Montreal as a transshipment terminal, thereby significantly increasing the tonnage through Montreal. Other Canadian foreign trades, such as Canada/Far East, have been ignored for two reasons. First, the tonnage moving on these services is small compared to the tonnage of the four trades analyzed. Secondly, a significant proportion of Montreal's tonnage for the other foreign trades probably has been classified as a domestic movement. For example, a portion of the Far East tonnage to and from Montreal has historically been transshipped at Vancouver and therefore has been included in the domestic statistics for the Montreal-Vancouver portion of the movement.

In order to determine the cargo in each of the trades listed above that will move through Montreal, we had to determine the points of origin/destination or the nodes of the cargo. Table 1 presents the Canadian nodes considered in this study. These nodes represent the Canadian Metropolitan Areas (CMA's) as defined by Dominion Bureau of Statistic (DBS) with two exceptions. We have included Charlottetown, P.E.I., in order to have at least one representative node to each Province. We have not included Sudbury, which is designated a CMA by DBS, because we could not find the necessary economic indicators to determine Sudbury's portion of the export cargo. The elimination of Sudbury as a node does not mean that the cargo to/from Sudbury has been eliminated but rather that the cargo has been assigned to the other CMA's within the Province of Ontario.

The Standard Metropolitan Statistical Areas (SMSA's) in the United States are similar to the CMA's in Canada. There are 116 SMSA's in the Great Lakes area and the northern portion of the East Coast. We have consolidated these 116 SMSA's into the 34 "consolidated" SMSA's in Table 2. Appendix A presents a list of the 34 consolidated SMSA's as well as the individual SMSA's included in each.

We have assumed that the CMA and SMSA nodes would be the origin and destination of the cargo moving in the trades analyzed. In order to assign the cargo to these nodes, we analyzed various economic indicators. We distributed the economic indicators to the CMA's and SMSA's to include areas that are not themselves CMA's or SMSA's. For example, Ontario has six CMA's. Ontario's population (one of the indicators we used) outside the six CMA's, was distributed to the CMA's in proportion to the population of the six.

Table 1

CANADIAN NODES

Code	
1	St. John's
2	Charlottetown
3	Halifax
4	Saint John
5	Montreal
6	Quebec City
7	Hamilton
8	Kitchener
9	London
10	Ottawa
11	Toronto
12	Windsor
13	Winnipeg
14	Regina
15	Saskatoon
16	Calgary
17	Edmonton
18	Vancouver
19	Victoria

Source: Canada Year Book 1969

Table 2

U.S. NODES

Code	
1	Wichita, Kansas
2	Kansas City, Missouri and Kansas
3	Omaha, Nebraska
4	Sioux City, Iowa
5	Fargo, North Dakota
6	Duluth, Minnesota
7	Minneapolis-St. Paul, Minnesota
8	Milwaukee, Wisconsin
9	Des Moines, Iowa
10	Dubuque, Iowa
11	Davenport, Iowa
12	Chicago, Illinois
13	Springfield, Illinois
14	St. Louis, Missouri
15	Evansville, Indiana
16	Louisville, Kentucky
17	Charleston, West Virginia
18	Indianapolis, Indiana
19	Toledo, Ohio
20	Detroit, Michigan
21	Grand Rapids, Michigan
22	Cleveland, Ohio
23	Cincinnati, Ohio
24	Erie, Pennsylvania
25	Pittsburgh, Pennsylvania
26	Buffalo, New York
27	Syracuse, New York
28	Albany, New York
29	Scranton, Pennsylvania
30	Baltimore, Maryland
31	Philadelphia, Pennsylvania
32	New York, New York
33	Hartford, Connecticut
34	Boston, Massachusetts

Source: Appendix A.

Table 3 presents a list of the European countries considered as nodes in this analysis. IATA includes all of these countries plus several North African and Mideast countries when defining North Atlantic traffic. We have not included the North African and Mideast countries because the total air cargo traffic is small and because data on the cargo flow to and from these countries were not readily available. We did not attempt to define the European nodes in finer detail than the country level because the additional detail would be of little or no use in determining the air cargo tonnage that will move through the new Montreal airport.

Cargo Data Base

As we stated above, if air cargo is to continue to grow at a rate higher than the growth rate for the total trade, it must continue to "steal" cargo from surface modes -- the high-value cargoes that are currently moving by surface transportation are the prime target to maintaining the high growth rates experienced in the past. Because of the penetration of air carriers into "surface" cargo, we included surface cargo, categorized by value, in the data base and consequently in the forecast of the total market.

We have recently conducted studies for several clients which entailed cargo forecasts of the basic services analyzed in this study. These forecasts are not directly applicable to the Montreal Airport study, because we were not specifically concerned with air cargo. However, most

Table 8

EUROPEAN COUNTRIES

Code	
1	Austria
2	Belgium-Luxembourg
3	Cyprus
4	Denmark
5	Finland
6	France
7	Germany (West)
8	Greece
9	Iceland
10	Ireland
11	Italy
12	Malta
13	Netherlands
14	Norway
15	Portugal
16	Spain
17	Sweden
18	Switzerland
19	Turkey
20	United Kingdom
21	Yugoslavia

of the base data we collected for these forecasts as well as the forecast growth rates themselves are applicable. Therefore, we used this accumulated information rather than developing an entirely new and original forecast. The base year for the forecasts we developed for other clients was 1969 and, hence, we used 1969 as the base year for the North Atlantic and transborder cargo. We used 1970 as the base year for the Canadian domestic cargo since it is latest available data. We attempted to collect the historical cargo flows in a manner which would allow the cargo to be allocated to the point of origin and point of destination (the nodes in Tables 1 through 3), the mode of transport (surface or air), and the value of the cargo.

The basic source for tonnage moving between Canada and Europe and the Canadian domestic cargo are various reports published by DBS. The basic source for the tonnage moving between the U.S. and Europe and between the U.S. and Canada were reports by the U.S. Bureau of the Census. These sources were supplemented by reports from other organizations, such as IATA and ICAO. Appendix B presents a full description of the data sources and the procedures used to develop the data base.

Tables 4 through 6 summarize the cargo data base for the various services analyzed. Most of the high-value cargo already moves by air in the North Atlantic service. In 1969 U.S. air exports were 208,000 short tons and imports to the U.S. were 188,000 short tons. The average value of air exports in that year was $6.88 per pound; air imports averaged $5.46 per pound. Cargo valued at $2.00 per pound or more now moving

Table 4

NORTH ATLANTIC CARGO, 1969
(Thousand Short Tons)

Value Range		Can. Surface Movements		Can. Air Movements		U.S. Surface Movements		U.S. Air Movements		Total	
$/lb		tons	%	tons	%	tons	%	tons	%	tons	%
Exports											
0.00	0.49	23,142	97.8	--	--	60,303	97.8	20	9.5	83,465	97.5
0.50	0.99	351	1.5	--	--	914	1.5	19	9.1	1,284	1.5
1.00	1.49	110	0.5	--	--	287	0.5	9	4.1	406	0.5
1.50	1.99	33	0.1	4	30.4	85	0.1	34	16.3	156	0.2
2.00	2.99	26	0.1	--	--	70	0.1	29	13.9	125	0.2
3.00	3.99	6	--	--	--	15	--	13	6.5	34	--
4.00	4.99	5	--	--	--	13	--	13	6.4	31	--
5.00	Up	7	--	10	69.6	18	--	71	34.2	106	0.1
Total		23,680		14		61,705		208		85,607	
Imports											
0.00	0.49	2,645	91.3	--	0.8	25,297	91.3	1	0.8	27,943	90.6
0.50	0.99	209	7.2	1	2.2	1,997	7.2	4	2.2	2,211	7.2
1.00	1.49	23	0.8	6	14.3	222	0.8	27	14.3	278	0.9
1.50	1.99	12	0.4	4	9.6	113	0.4	18	9.6	147	0.5
2.00	2.99	5	0.2	5	13.8	50	0.2	26	13.8	86	0.3
3.00	3.99	2	0.1	11	27.0	17	0.1	51	27.0	81	0.3
4.00	4.99	--	--	2	5.6	4	--	11	5.6	17	--
5.00	Up	--	--	11	26.7	3	--	50	26.7	64	0.2
Total		2,896		40		27,703		188		30,827	

Source: Canada - See Appendix B.
U.S.A. - U.S. Bureau of the Census reports FT 155 and FT 455
U.S. Foreign Trade, World Area by Commodity Groupings
and Method of Transportation, 1969.

Table 5

TRANSBORDER CARGO, 1969
(Thousand Short Tons)

	Value Range $/lb		Surface Movements		Air Movements		Total	
			tons	%	tons	%	tons	%
Southbound								
	0.00	0.99	26,543	99.4	1	11.1	26,544	99.3
	1.00	1.49	143	0.5	4	44.5	147	0.6
	1.50	1.99	7	--	--	--	7	--
	2.00	2.99	27	0.1	--	--	27	0.1
	3.00	3.99	3	--	1	11.1	4	--
	4.00	4.99	--	--	--	--	--	--
	5.00	Up	--	--	3	33.3	3	--
	Total		26,723		9		26,732	
Northbound								
	0.00	0.99	7,781	93.2	5	16.0	7,786	93.0
	1.00	1.49	327	3.9	2	6.5	329	3.9
	1.50	1.99	123	1.5	3	9.7	126	1.5
	2.00	2.99	76	0.9	7	25.8	84	1.0
	3.00	3.99	15	0.2	2	6.5	17	0.2
	4.00	4.99	8	0.1	2	6.5	10	0.1
	5.00	Up	16	0.2	9	29.0	25	0.3
	Total		8,346		30		8,377	

Source: U.S. Bureau of the Census Reports FT 155 and FT 455; Appendix B.

Table 6

MONTREAL'S DOMESTIC CARGO, 1970
(Thousand Short Tons)

	Value Range $/lb		Surface Movements		Air* Movements		Total	
			tons	%	tons	%	tons	%
Outbound								
	0.00	0.99	40,129	97.9	5	15.0	40,134	97.8
	1.00	1.49	549	1.3	5	15.0	554	1.3
	1.50	1.99	152	0.4	2	7.5	154	0.4
	2.00	2.99	120	0.3	6	20.0	126	0.3
	3.00	3.99	21	0.1	2	7.5	23	0.1
	4.00	4.99	10	--	2	5.0	12	--
	5.00	Up	19	--	10	30.0	29	0.1
	Total		41,000		32		41,032	
Inbound								
	0.00	0.99	21,533	97.9	3	15.0	21,536	97.8
	1.00	1.49	295	1.3	3	15.0	298	1.3
	1.50	1.99	82	0.4	2	7.5	84	0.4
	2.00	2.99	64	0.3	4	20.0	68	0.3
	3.00	3.99	11	0.1	2	7.5	13	0.1
	4.00	4.99	5	--	1	5.0	6	--
	5.00	Up	10	--	6	30.0	16	0.1
	Total		22,000		21		22,021	

* Includes double handling due to transshipped cargo.

by sea is less than the present air movement. The capture of all U.S. and Canadian surface cargo valued at over $3.00 per pound would have increased total North Atlantic air freight by 20 per cent in 1969. The capture of all U.S. and Canadian surface cargo valued at over $2.00 per pound would have increased total North Atlantic air freight by 54 per cent. In 1970 and 1971 total North Atlantic air cargo volumes did not increase; there was a slight decrease in 1970, and 1971 will show a slight increase. The Canadian North Atlantic traffic increased during these two years while U.S. traffic decreased.

Only a small proportion of the high-value transborder cargo is carried by air. If all surface cargo valued at over $3.00 per pound were carried by air, the transborder air freight would have increased by 108 per cent in 1969. The capture of all surface cargo valued over $2.00 per pound would have increased air freight 372 per cent. The proportion of high-value transborder cargo carried by air is significantly smaller than the proportion in the North Atlantic service because the distances are significantly smaller. A small proportion of Montreal's domestic cargo moves by air for the same reason -- short distances.

Most Canadian air cargo moves long distances -- both domestic and international (which includes transborder traffic). Table 7, which shows the air freight growth of Canadian airlines, illustrates the distance distribution. While U.S. domestic air cargo moves an average of 2,100 kilometers, the average for Canada has grown to 2,500 kilometers,

Table 7

FREIGHT GROWTH, CANADIAN SCHEDULED AIRLINES

	Domestic		International		
Year	Metric Tons	Average Distance km	Metric Tons	Average Distance km	Total Metric Tons
a) All airlines					
1966	43,670	2,010	25,570	2,710	69,240
1967	46,620	2,060	26,940	3,180	73,560
1968	55,850	2,140	35,910	3,740	91,760
1969	58,700	2,190	42,120	4,140	100,820
1970	60,920	2,510	47,910	4,340	108,830
b) Air Canada					
1966	30,840	2,350	21,870	2,100	52,710
1967	33,090	2,420	22,160	2,450	55,250
1968	40,290	2,450	29,570	3,110	69,860
1969	39,980	2,600	34,260	3,650	74,240
1970	41,840	2,950	39,870	4,050	81,710
c) CP Air					
1966	4,140	1,820	3,700	6,520	7,840
1967	3,860	1,860	4,790	6,520	8,650
1968	5,510	2,160	6,340	6,480	11,850
1969	6,360	2,150	7,850	6,400	14,210
1970	8,090	2,310	8,040	5,700	16,130
d) Other domestic airlines					
1966	8,700	890			
1967	9,670	860			
1968	10,060	820			
1969	12,370	880			
1970	-	-			

Source: Digest of Statistics, No. 159, ICAO.

even though Canadian population and industry are more highly concentrated, along the Windsor-Quebec corridor, than are U.S. population and industry. This would indicate that the use of air cargo in Canada is reserved for long hauls into and out of the industrial and population centers, and for movements to the less accessible areas.

Commodities that are susceptible to movement by air are primarily classified by their value. We have presented later in this chapter and in Appendix D, the value of the cargo that will move by air in the future. Tables 8 and 9 present the major commodities that moved in the U.S.-Europe service in 1969 and 1970. It is interesting to note that perishable items such as food, flowers and some varieties of live animals are not among the list. In fact, food and live animals amounted to between 7,000 and 7,500 tons in 1969 and 1970, respectively, in the U.S. to Europe service. There were no major changes in the major commodities, their value or the proportion moving by air in the two years. The commodities shown in the tables account for more than 80 per cent of the cargo moved by air.

Table 10 presents the major commodities moving in the transborder service in 1970. These commodities account for more than 80 per cent of the tonnage moving in the transborder service that year. Unfortunately, the statistics for the Canada-Europe service and the Canadian domestic service do not specify major commodities by weight so we are unable to present comparable data for these services (see Appendix B). Table 11 presents the major commodities by value moving by air from Canada to Europe. Two commodities which had large export value were

Table 8

MAJOR AIR CARGO COMMODITIES
U.S.-EUROPE, 1969

	Tons Moved		Per Cent	Value/Pound	
Commodity	Air	Vessel	By Air	Air	Vessel
Exports	000 ST			$	
51 Chemical elements	5.7	3,743.9	0.2	5.63	0.07
54 Medical & pharmaceutical	1.4	6.5	17.9	25.18	2.80
58 Synthetic resins	6.0	372.7	1.6	1.26	0.30
65 Textile yarn fabrics	10.6	81.2	11.5	2.22	0.83
67 Iron and steel	7.8	2,206.8	0.4	0.62	0.06
68 Nonferrous metals	3.4	339.0	1.0	8.34	0.58
69 Mfg of metals, NEC	5.1	59.8	7.9	3.67	0.78
71 Machinery, nonelectric	56.3	408.2	12.1	8.31	1.33
72 Electrical machinery	21.2	87.5	19.5	16.71	1.15
73 Transport equipment	13.6	141.2	8.8	8.87	1.16
84 Clothing & acces	1.8	12.8	12.5	5.15	2.16
86 Meas instruments	11.4	25.9	30.5	11.08	2.84
89 Misc mfg, NEC	15.4	52.4	22.8	6.86	1.33
93 Special transactions	11.9	21.0	36.1	1.79	0.40
These total	171.6	7,558.9	2.2	7.90	0.24
All total	208.1	61,704.7	0.3	6.88	0.06
Imports					
53 Dyeing, tanning materials	2.3	29.1	7.4	2.61	0.96
61 Leather & mfg	3.5	9.8	26.3	5.62	1.70
65 Textile yarn fabrics	16.1	169.0	8.7	3.16	0.64
69 Mfg of metals, NEC	6.0	474.9	1.2	2.80	0.22
71 Machinery, nonelectric	35.1	578.9	5.7	4.40	0.83
72 Electrical machinery	17.3	208.5	7.7	5.69	0.58
73 Transport equipment	4.5	1,062.0	0.4	5.94	0.69
84 Clothing & acces	14.3	8.9	61.6	7.58	3.12
85 Footwear	24.0	50.3	32.3	3.15	1.82
86 Meas instruments	8.5	21.6	28.3	14.65	2.22
89 Misc mfg, NEC	16.3	166.5	8.9	7.50	1.04
99 Goods, value under $251	15.2	55.2	21.6	1.22	0.30
These total	163.1	2,834.7	5.4	5.04	0.69
All total	188.0	27,702.8	0.7	5.47	0.13

Source: U.S. Bureau of the Census, Reports FT 155 and FT 455, 1969.

Table 9

MAJOR AIR CARGO COMMODITIES
U.S.-EUROPE, 1970

Commodity	Tons Moved		Per Cent by Air	Value/Pound	
	Air	Vessel		Air	Vessel
	000 ST			$	
Exports					
51 Chemical elements	4.6	3,634.2	0.1	4.75	0.09
54 Medical & pharmaceutical	1.5	8.9	14.7	26.18	3.36
58 Synthetic resins	4.3	373.3	1.2	1.50	0.33
65 Textile yarn fabrics	8.2	66.3	11.0	2.12	0.76
67 Iron and steel	7.2	4,152.2	0.2	0.59	0.06
68 Nonferrous metals	3.8	467.0	1.0	6.27	0.48
69 Mfg of metals, NEC	6.0	68.0	8.1	3.98	0.82
71 Machinery, nonelectric	59.9	479.6	11.1	10.54	1.49
72 Electrical machinery	25.9	114.6	18.4	15.33	1.25
73 Transport equipment	11.7	171.5	6.4	12.98	1.12
84 Clothing & acces	1.0	8.9	10.5	6.34	2.20
86 Meas instruments	10.9	31.7	25.7	12.56	2.98
89 Misc mfg, NEC	18.5	56.0	24.9	5.05	1.39
93 Special transactions	17.4	46.5	27.2	2.33	0.37
These total	180.9	9,678.7	1.8	8.81	0.24
All total	211.5	77,226.9	0.3	7.86	0.06
Imports					
53 Dyeing, tanning materials	1.2	35.7	3.2	2.63	0.93
61 Leather & mfg	3.0	11.2	20.8	4.97	1.57
65 Textile yarn fabrics	17.4	207.7	7.7	3.24	0.81
69 Mfgs of metal	5.4	394.1	1.4	2.75	0.30
71 Machinery, nonelectric	30.3	675.8	4.3	4.89	0.89
72 Electrical machinery	14.5	235.3	5.8	6.92	0.62
73 Transport equipment	5.3	1,183.2	0.4	5.35	0.74
84 Clothing & acces	14.4	10.1	58.7	7.35	3.19
85 Footwear	25.0	70.0	26.3	3.26	1.89
86 Meas instruments	7.8	25.0	23.7	16.44	2.54
89 Misc mfg, NEC	16.0	173.2	8.5	6.98	1.15
99 Goods, value under $251	16.4	52.4	23.9	1.22	0.30
These total	156.7	3,073.7	4.8	5.19	0.78
All total	176.3	28,364.6	0.6	5.78	0.15

Source: U. S. Bureau of the Census, Reports FT 155 and FT 455, 1970.

Table 10

MAJOR AIR CARGO COMMODITIES
U.S.-CANADA, 1970
(Short Tons)

		To Canada	From Canada
93 -	Special transactions not classified by kind	9,960	1,016
71 -	Machinery, non electric	5,326	1,045
89 -	Miscellaneous manufactured articles, nec.	3,909	700
72 -	Electrical machinery, apparatus and appliances	3,812	1,104
69 -	Manufactures of metal, nec.	2,577	448
73 -	Transport equipment	2,409	788
86 -	Professional photography goods, clocks	1,573	266
67 -	Iron and steel	773	90
99 -	Establish value under $251	-	2,913
	These total	30,339	8,370
	All commodities total	36,861	10,218

Source: U.S. Bureau of the Census Reports FT 155 and FT 455, 1970.

Table 11

MAJOR AIR CARGO COMMODITIES CANADA TO EUROPE, 1969

Commodity Number	Description	Air Value $000
195	Laboratory equipment, measuring, etc.	14,941
55	Fur skins, undressed	14,153
205	Miscellaneous apparel	12,935
198	Office machinery & equipment	12,628
186	Commercial & industrial communications equipment	6,507
170	Other special industrial machinery	4,354
110	Special construction fabrics	3,838
188	Communications & related equipment	3,697
215	Medicinal & pharmaceutical products	3,523
180	Other vehicle engine parts & access.	2,914
223	Works of art & collector's items	2,310
192	Electric lighting & control equipment	2,140
169	Woodworking machinery	2,022
76	Nickel in ores, concentrate, straps	1,718
109	Other broad woven fabrics	1,590
168	Metalworking machinery	1,180
	Total	90,450
	Other	22,921
	Grand Total	113,371

Source: Exports by Mode of Transport, DBS, 1969.

omitted from this list. The first was precious metals (ores, concentrate and scrap) which and exports valued at $28,965,000 in 1969. This commodity was omitted because although the total value was high, the tonnage exported was small. The second commodity omitted was aircraft with exports valued at $23,803,000 in 1969. This commodity was eliminated from the list because we could not determine the extent to which the aircraft were delivered under their own power.

We expect that these same commodities will constitute the principal air cargo commodities of the future -- that is, we expect that the future growth in air movements will be concentrated in these commodities shown in Table 8 through 11 rather than commodities that are not currently moving by air.

We must note here that the definition of cargo valued at more than X dollars per pound is not the actual weight of such cargo. It is obtained by adding together all four-digit commodity classes moving by sea which had an average value of X dollars per pound or more in 1969. These estimates of tonnage by value class are therefore to be taken as guidelines rather than as precise statements.

We analyzed the U.S. import and export commodities to determine their containerizability, that is, to determine if the cargo is physically capable of being transported by a container. We used data that were developed from extensive surveys of several different trades. Our data are based on the four-digit commodity level as defined in Schedules A and B, U.S. Bureau of the Census. Since the Bureau of the Census keeps its statistics on the seven-digit level, and since air cargo historically has been small relative to surface movements, our containerizability data may not be completely accurate as far as air cargo is concerned. In any event, if we were to assume that cargo must be containerizable in order to be transported by air, and assuming our containerizability factors are correct, the U.S. North Atlantic cargo data base (Table 4) should be adjusted by the following percentages:

Cargo Value $/lb	Per Cent Containerizable	
	Exports	Imports
$1.00 - 1.99	84	91
2.00 - up	89	98

The cargo data base for the other services should probably be adjusted by similar amounts.

Total Market Forecast

This section describes the forecast of the total cargo presented in Tables 4 through 6. In the next section, we will discuss our forecast of the portion of the future market that will move by air and compare our air forecast with several others that have appeared in the literature.

All data used in the development of the total market forecast predates the recent monetary revaluation as the basic forecasts were made in early or mid-1971. It is too early yet to see any effects of revaluation; the on-again/off-again longshore strikes will probably have a larger effect on U.S. foreign trade in 1971 and 1972 than revaluation. Third and fourth quarter statistics for 1971 air cargo movements were not available at the time the forecasts were made.

We have developed average growth rates for each of the services considered in studies for other clients. The average growth rates, presented in Table 12, were developed by a detailed analysis of the principal commodities and the economic characteristics of the trading partners involved.

These growth rates were developed for a series of different studies which explains the varying levels of detail in the table. The growth rates apply to the total areas shown in the table. In other words, we assumed that the growth rate for U.S. cargo to all the Scandinavian countries, for example, would be the same. The Canadian growth rates apply to the total service. That is, Canadian to/from Belgium would have the same growth rate as France, the U.K. or any other European country.

The forecast tonnage for all services was allocated to the CMA's and SMSA's using forecasts of the appropriate indicators (population in the case of imports and value of exports or value added in the case of exports) for each center. The result of the forecast effort is a series of matrices estimating the tonnage moving from a point of origin to a point of destination for all services except Canadian domestic. In this case, the forecast is simply an estimate of the tonnage moving into and out of the Montreal area.

Table 12

AVERAGE CARGO GROWTH RATES

	Growth Rates	
	1970-1975	1975-1985
	%	%
North Atlantic Service		
Canadian exports	3.8	3.8
Canadian imports	3.0	3.0
U.S. exports to:		
United Kingdom and Eire	0.8	4.6
Baltic and Scandinavia	6.8	4.1
Bayonne-Hamburg range	1.8	4.6
Portugal and Spanish Atlantic	12.7	4.6
Azores, Mediterranean and Black Sea	4.5	5.0
Average	2.6	4.6
U.S. imports from:		
United Kingdom and Eire	4.4	6.2
Baltic and Scandinavia	0.2	6.0
Bayonne-Hamburg range	6.6	6.0
Portugal and Spanish Atlantic	2.0	4.3
Azores, Mediterranean and Black Sea	4.2	5.6
Average	4.8	5.9
Transborder Service		
Southbound	6.6	6.6
Northbound	6.0	6.0
Canadian Domestic	5.4	5.4

Figure 1 illustrates the organization of the data as well as the forecast, in this case the cargo moving from Canada to Europe. This example figure is useful in forecasting the growth of air cargo because the implications of further penetration into what has been surface cargo can be readily determined. Air cargo growth from 1962 to 1969 is the basic trend line. In 1969 we add to the air cargo the existing surface cargo starting from the highest-value commodities. Thus, the first point above the trend line is the weight of the actual 1969 air cargo plus all surface cargo valued at $5.00 per pound or higher. The next point is the weight of the actual 1969 air cargo plus all surface cargo valued at $4.00 per pound or higher. This is continued until we include all surface cargo valued at $1.00 per pound or higher.

We extended the 1969 estimates into the future under the assumption that trade in all value groups will grow at the same rate -- using the growth rates given in Table 12. The topmost line then represents the estimated air cargo plus the surface cargo valued at $1.00 per pound or more for the years 1969 to 1990.

Canada's eastbound North Atlantic air cargo has increased at a rate of 23 per cent per year in the period 1962-1969. A continued increase at the same rate would imply that by 1975 all Canadian exports to Europe valued at about $2.80 per pound or more would move by air. While this may be feasible in this case, we do not believe it is feasible in all cases. For example, U.S. exports to Europe have also been growing at 23 per cent per year between 1962 and 1969. Continued growth at this

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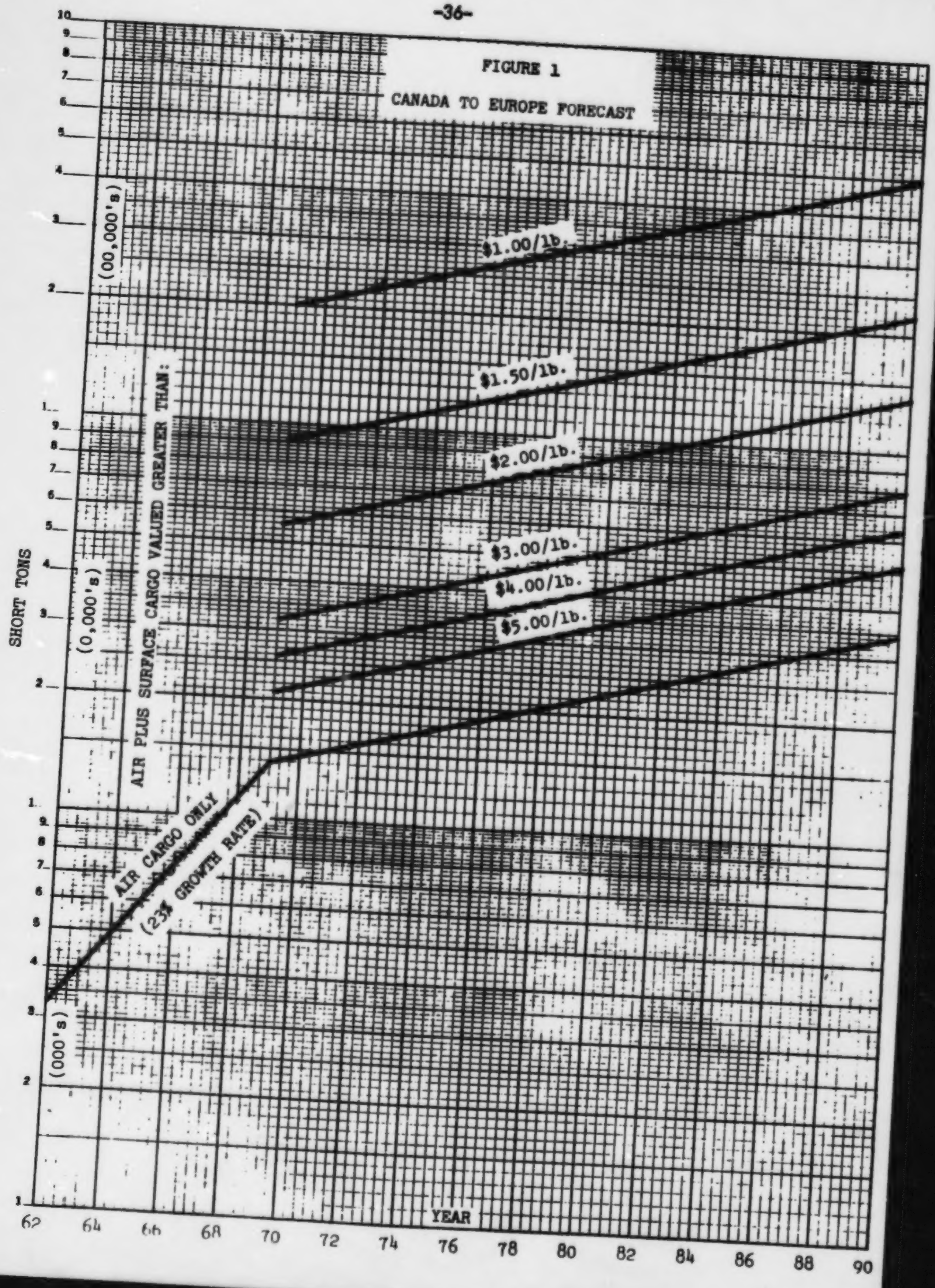

FIGURE 1

CANADA TO EUROPE FORECAST

rate implies that all cargo valued at about $1.00 per pound or more would move by air in 1976 and we feel that this is unlikely.

Appendix C presents summary curves similar to Figure 1 for the remaining services and the detailed forecasts broken down by node of origin and destination.

Air Cargo Market Forecast

In this section we discuss the development of the air cargo market; that is, the proportion of the total market that will move by air. We will discuss Montreal's share of the air cargo market in the next section.

A number of forecasts of North Atlantic air cargo movements have been reported in the literature, and several of these are included in Figure 2. The data in Figure 2 are the total of eastbound and westbound cargo flows. In making comparisons, we must note that the forecasts are not all for identical parameters. The ICAO 1966 forecast* is for cargo only and has been extended to 1975. The 1970 ICAO forecast** includes both cargo and mail and extends to 1980. The 1970 ICAO forecast has added yet another parameter; namely, the allocation of cargo between passenger and all-cargo aircraft. The 1970 TRCS forecast*** is for U.S.

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* ICAO Circular 76-At/11 "North Atlantic Traffic Forecasts" (March 1966) pp. 14-19.

** ICAO Ref T17/1.IN-562 "Ten Year North Atlantic Traffic Forecast for the Period 1971-1980" 20 April 1971, pp. 14-16.

*** Transportation Research & Computer Systems, Inc., as quoted in Jet Cargo News, November 1971, pp. 20, 23.

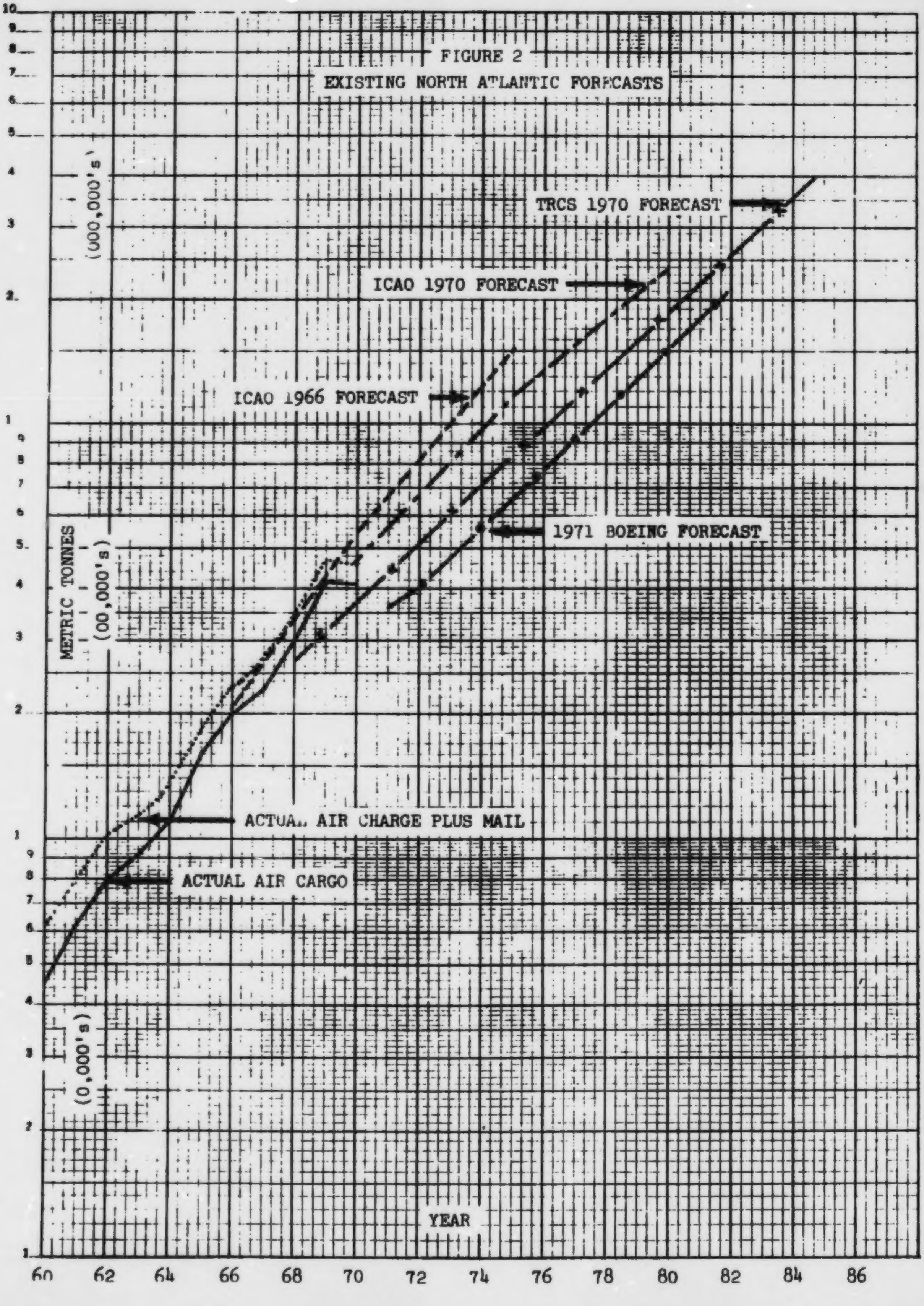

FIGURE 2

EXISTING NORTH ATLANTIC FORECASTS

North Atlantic cargo only; this forecast was presented as a single number based on growth from 1968 at a rate of about 18 per cent per year. The Boeing* forecast made in 1971 (for 1971-1980) is again for U.S. cargo only and is subdivided by individual country and by direction.

In contrast to all the above, the growth of air cargo within Canada and for the U.S./Canada trades has received little attention, and no forecasts have appeared in the literature. Much more effort has been expended on forecasting the growth of U.S. domestic air freight. In some such analyses, both the Canadian domestic and the U.S./Canadian movements are included within the U.S. domestic air freight. One cannot, however, assume that the Canadian trades will show the same growth rates as those of the U.S. The last two years, for example, have seen little or no increase in U.S. domestic and U.S. North Atlantic ton-miles, while Canada's North Atlantic, U.S. and domestic tonnages and ton-miles have all increased over the same period. The apparent decline in air cargo movements between 1969 and 1970 in Figure 2 was caused not so much by an actual decline of 1970 movements but rather by artificially high movements in 1969 apparently caused by a 113-day maritime strike which started December 21, 1968. The leveling off of air cargo movements between 1970 and 1971 was probably caused by the international financial crisis which eventually led to the devaluation of the U.S. dollar.

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* U.S. - Europe Air Cargo, Air Cargo Analysis and Development Unit, The Boeing Company, November 1971.

We have based our air cargo forecasts on past rates of air cargo growth, the rate of growth of total trade in these markets, and the distribution of surface cargo by value per pound. This last factor then introduces the concept of competition between surface and air modes. Where North Atlantic cargo is concerned, the value per pound is a dominant factor because all distances are long and we need not be concerned with the precise distance that cargo moves. For the other trades, domestic and transborder, the distance to market will play an important role in modal choice -- air movements will be less attractive for short distances.

North Atlantic trades

The North Atlantic trades are now served by modern container ships with frequent sailings. Such vessels can compete with air carriage much more effectively than the conventional break-bulk vessels, and tend to reduce the rate of growth of air cargo.

In selecting the future growth rates of air cargo, we took into consideration not only the value of cargo, past historical growth and competition by container services, but also the cost trends in both air and sea movement. Direct operating costs of both passenger and cargo aircraft will not be lower than present costs. Cost reduction can only come about by: 1) higher aircraft utilization; and 2) reduced terminal costs. We see a surplus of capacity up to 1975 and cannot anticipate significantly higher utilization until then. Automated terminals have thus far not produced the anticipated reductions in handling costs. There are economies of scale, but many terminals are already of a size that further scale economies cannot be obtained unless procedures, cargo mix and productivity can be improved.

Even with the present cost structure, air cargo will continue to grow by capturing the major share of high-value traffic moving long distances. Given the general conditions in the airline industry, we do not anticipate general rate reductions on major routes or a wide extension of commodity rates in the next five years.

Taking these factors into account and considering the Canada to Europe trade, for example, we estimate that air cargo will grow at a rate of 15 per cent per year in the period 1970-1975 -- implying that air cargo will include all commodities averaging about $4.10 per pound or more. We estimate that the range of possible growth rates in the period 1970-1975 will be between 10 and 20 per cent (most likely 15 per cent) and between 8 and 12 per cent (most likely 10 per cent) in the period 1975-1980. The resulting forecast of air cargo is superimposed on the total market forecast in Figure 3. Appendix D presents similar figures and summaries of the air cargo growth rates for the other North Atlantic services analyzed.

Figures 4 and 5 compare our North Atlantic forecasts with the 1970 ICAO forecast and the 1971 Boeing forecast respectively. Once again, the data presented in these figures are expressed in metric units and

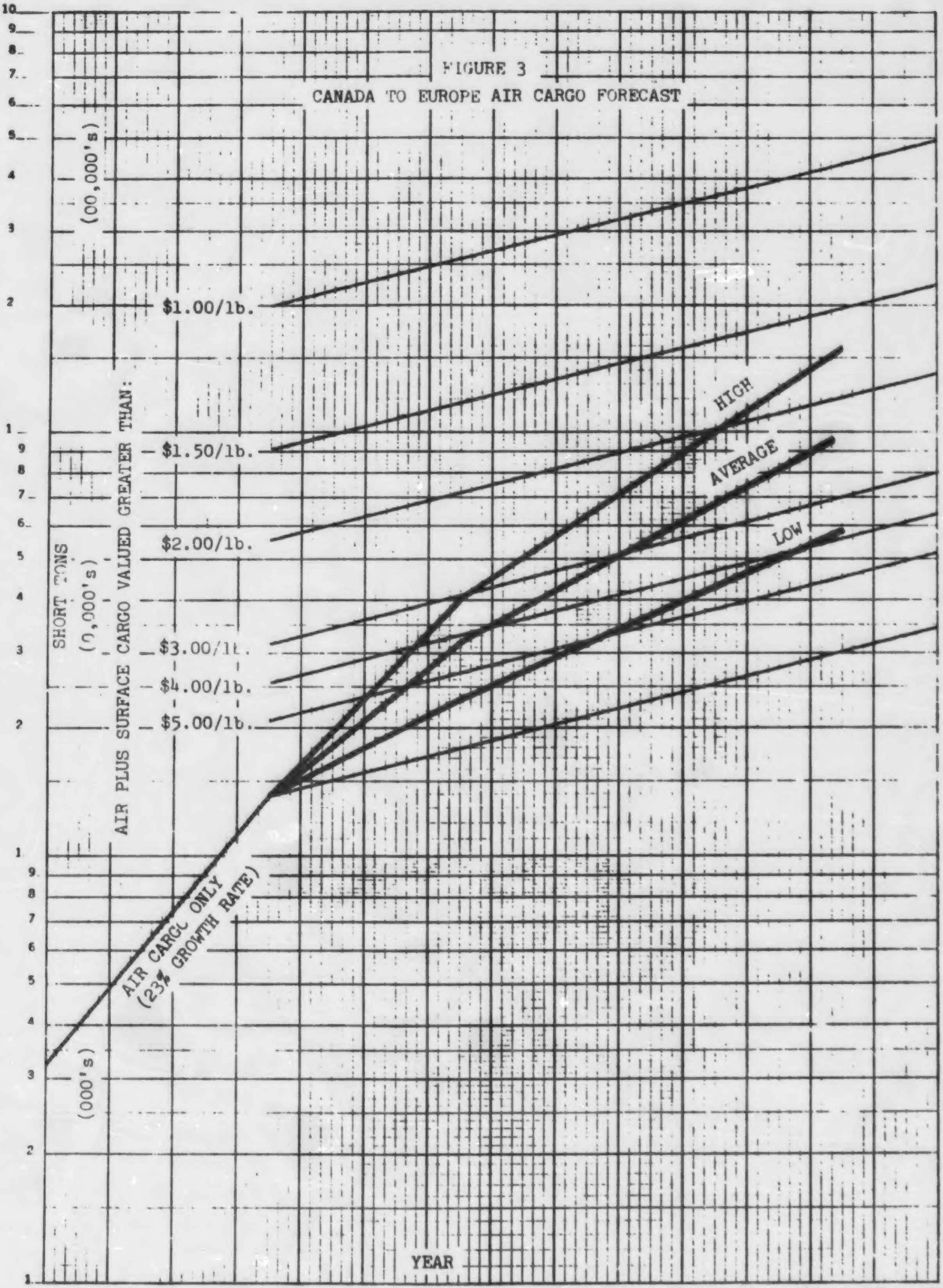


FIGURE 3

CANADA TO EUROPE AIR CARGO FORECAST

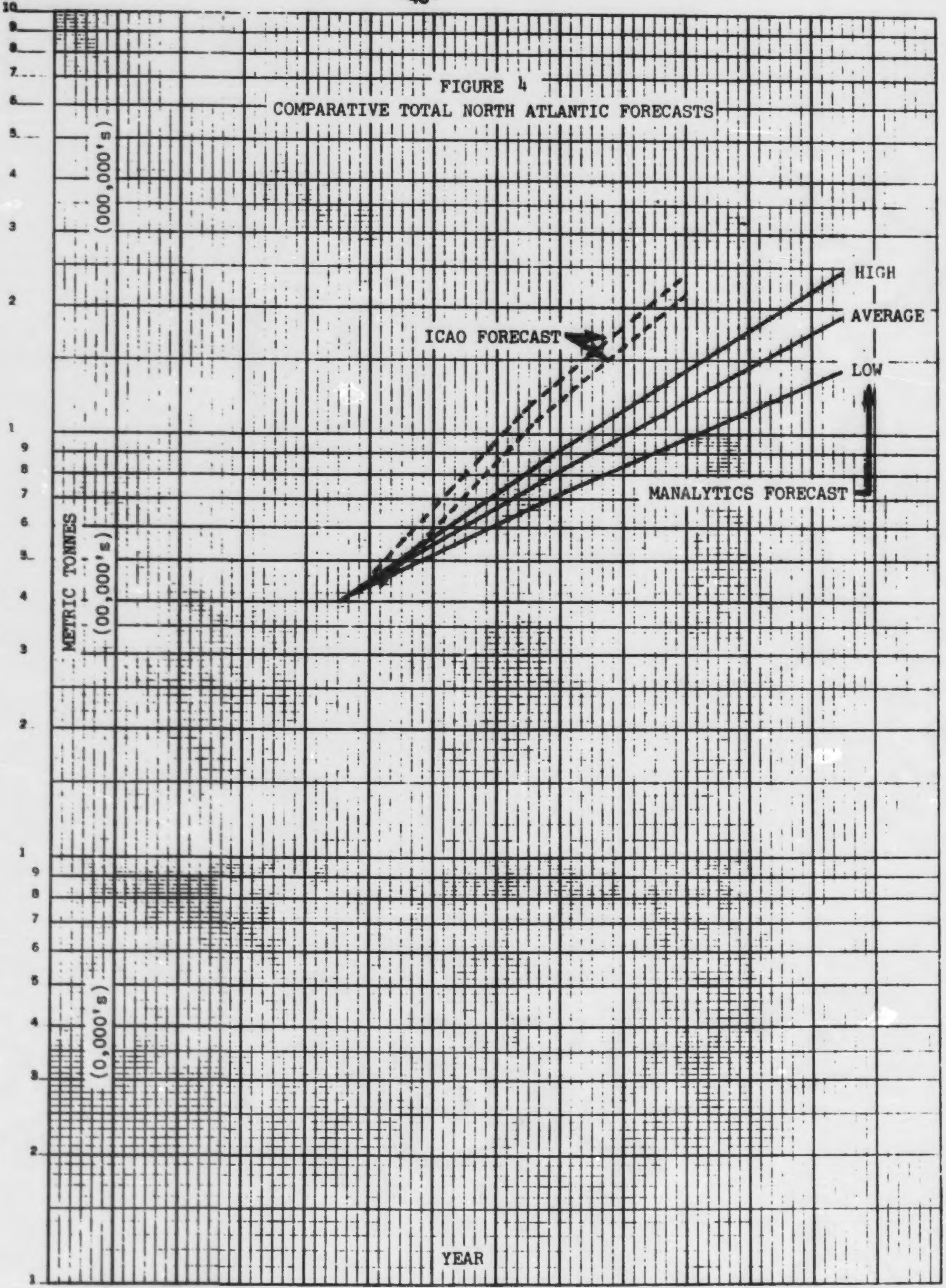


FIGURE 4
COMPARATIVE TOTAL NORTH ATLANTIC FORECASTS

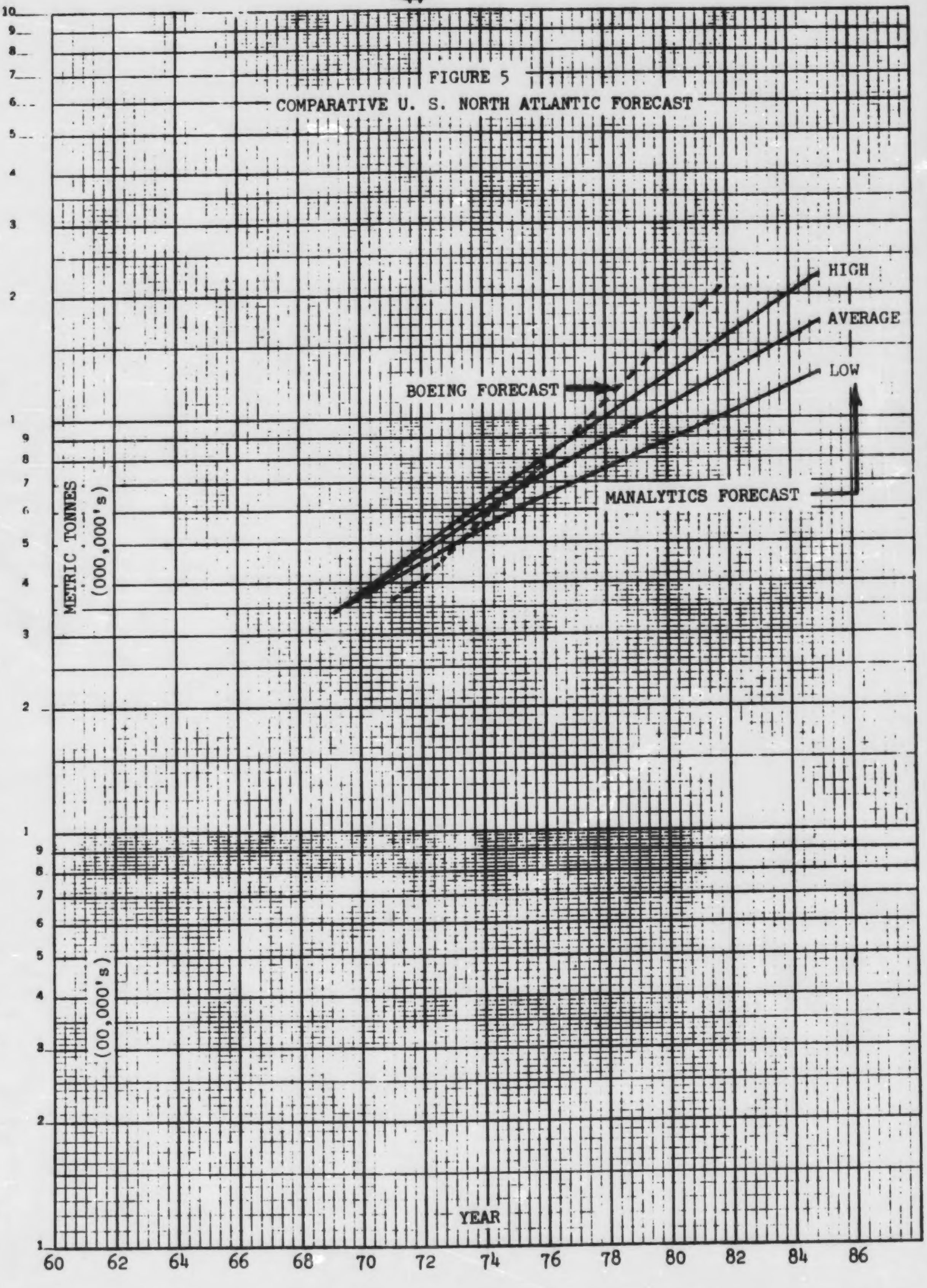


FIGURE 5

COMPARATIVE U. S. NORTH ATLANTIC FORECAST represent the total eastbound and westbound traffic. ICAO forecast total North Atlantic traffic (Canada plus U.S.) and included mail moving by air. The top ICAO "line" in Figure 4 represents the cargo-plus-mail forecast. Since mail averaged 10 per cent of the total North Atlantic movement over the last several years, we reduced the total ICAO forecast 10 per cent to simulate our ICAO cargo-only forecast which is represented by the bottom ICAO "line" in Figure 4. The ICAO forecast implies all surface cargo valued greater than $1.00 per pound will move by air in 1980. We feel this is an optimistic forecast.

Boeing has forecast only U.S. air cargo. Our forecasts for U.S. air cargo are in close agreement with Boeing's (Figure 5) for the period 1971-1975, although we have used different approaches. The Boeing forecast is based on linear regression techniques which show a high correlation between tons and two independent factors, GNP of the importing country and revenue per ton-mile. We used the same regression in an earlier study to develop a forecast of U.S. domestic air cargo. We did not follow that procedure in this case for two reasons: because we did not feel that we could obtain reliable forecasts of GNP (particularly for European countries) and because we found that only a small portion of high-value cargo is still moving by sea in the North Atlantic trades.

Our forecasts and Boeing's diverge for the period 1975-1980 (Boeing's limit) because they have predicted a further rise in the growth of GNP for both Europe and North America and a decrease in air cargo tariffs. We are less optimistic. It must be noted that Boeing's 1971 forecast is significantly lower than their forecast of world air cargo in 1969. They are to be commended for their thorough analysis and excellent report.

Transborder traffic

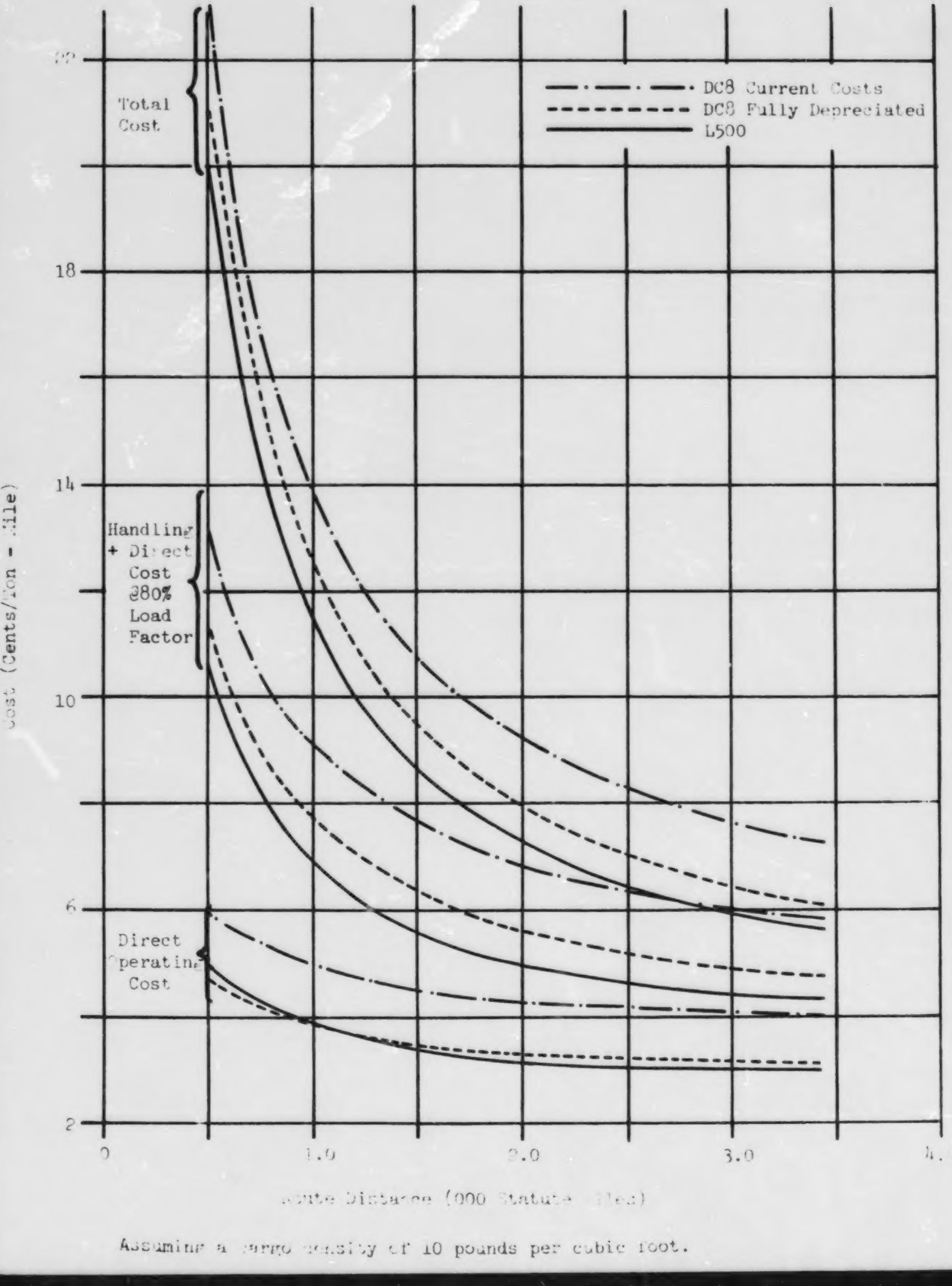
U.S./Canada cargo movements by air totaled 39,000 tons in 1969, northbound movements exceeding southbound movements by a factor of three. Air has a smaller share of this market, both in value and tonnage terms, than of the North Atlantic markets. This smaller market share will persist because of the relatively short distances between major population and manufacturing centers in the two countries. There is a significant volume of commodities with average value in excess of $1.00 per pound now moving by surface (about twenty times larger than present air cargo volumes). Because of the short distance between markets, much of this cargo will continue to move by surface and we only anticipate a doubling of the air share of the higher-value cargoes by 1985.

The same general assumptions on tariffs and costs stated for North Atlantic traffic holds for the transborder traffic. Transborder and domestic air cargo is not competitive for short distances because of the costs per ton-mile of air movements. Figure 6, drawn from an earlier report on air cargo, illustrates the effects of distance on both direct and indirect costs. This is also confirmed by the long average haul of Canadian domestic cargo shown in Table 8.

Appendix D presents figures showing the growth in transborder air cargo compared to the growth in total transborder cargo and summaries of the transborder growth rates.

Figure 6

OPERATING COST OF CARGO AIRCRAFT



Assuming a cargo density of 10 pounds per cubic foot.

Domestic traffic

We have estimated the share of Canadian domestic freight movement that can be assigned to the Montreal region (defined as Montreal and Ottawa CMA's and environs) for each value class of interest. Historical growth of air cargo inbound and outbound for the region has averaged over 25 per cent per year, but continuation of this rate of growth would imply air movement of all freight worth $3.00 per pound or more. Considering the relative closeness of Montreal to Toronto, its major domestic trading market, and the long average distance of movement of cargo currently moving by air (Table 7) we anticipate a slow-down of the growth rate to the range of 12 to 18 per cent per year for the period 1971-1975 and 8 to 12 per cent per year in the period 1976-1985. This estimate is optimistic because since 1966 domestic air tonnage by scheduled airlines has increased at a rate of only 9 per cent per year.

We estimate that 60 per cent of the "Air Cargo Only" portion of the domestic air cargo forecast is cargo originating or terminating in the Montreal/Ottawa area, 20 per cent is domestic transshipments and 20 per cent is international transshipments. The "surface" portion of the air cargo forecast is assumed to originate or terminate in the Montreal/Ottawa area.

Total air cargo forecast tons

The low, average and high forecasts of air cargo for the period between the base year and 1985 are presented in Table 13. The base year is 1969 for all services except the Canadian domestic service

Table 13

AIR CARGO FORECASTS
(Thousands Short Tons)

	Base Year	1975	1980	1985
Low Forecast				
Canada - Europe	14	24	35	51
Europe - Canada	40	56	75	100
U.S. - Europe	210	340	500	740
Europe - U.S.	190	315	460	680
Canada - U.S.	9	15	23	35
U.S. - Canada	30	53	79	115
Domestic - Outbound	32	57	84	123
Domestic - Inbound	21	35	52	77
Total	546	895	1,308	1,921
Average Forecast				
Canada - Europe	14	32	52	82
Europe - Canada	40	63	93	135
U.S. - Europe	210	380	600	980
Europe - U.S.	190	350	560	900
Canada - U.S.	9	19	46	63
U.S. - Canada	30	59	94	150
Domestic - Outbound	32	66	102	162
Domestic - Inbound	21	40	65	105
Total	546	1,009	1,612	2,577
High Forecast				
Canada - Europe	14	41	71	125
Europe - Canada	40	72	105	155
U.S. - Europe	210	410	710	1,250
Europe - U.S.	190	380	680	1,200
Canada - U.S.	9	22	46	95
U.S. - Canada	30	69	121	212
Domestic - Outbound	32	77	136	240
Domestic - Inbound	21	46	81	144
Total	546	1,117	1,950	3,421

where 1970 is the base year. Once again, the domestic forecasts are forecasts of the domestic tonnage handled in Montreal and not the tonnage originating or terminating in Montreal.

Forecast of Montreal Air Freight Volume

In the previous section we presented the forecasts of the total North Atlantic air cargo movements to and from Canada and the United States, and the total transborder air freight by direction. A Montreal air cargo center will handle only a portion of these trades under any reasonable set of assumptions.

To estimate Montreal's share we have estimated the demands of most Canadian CMA's and most of the United States SMSA's for imports, and their potential for exports (see Appendix C for details). The analysis follows work we have carried out for U.S. and Canadian government agencies. In addition, we have considered the allocation of cargo to passenger aircraft in the North Atlantic service, after estimating the required passenger fleet and its assignment to major passenger centers.

For purposes of discussion and evaluation of North Atlantic and transborder air freight, we have divided Canada and the U.S. market into the regions shown in Figure 7. The eastern CMA's are those CMA's that cannot be served by overnight truck delivery from a major air center and hence the European and transborder air cargoes must be transshipped by air from a major center such as Montreal. The central Montreal region, consisting of Montreal, Ottawa and Quebec City, will be served by the new Montreal airport. East Ontario contains those Ontario CMA's (except Ottawa) that could be served by overnight truck delivery from Montreal.

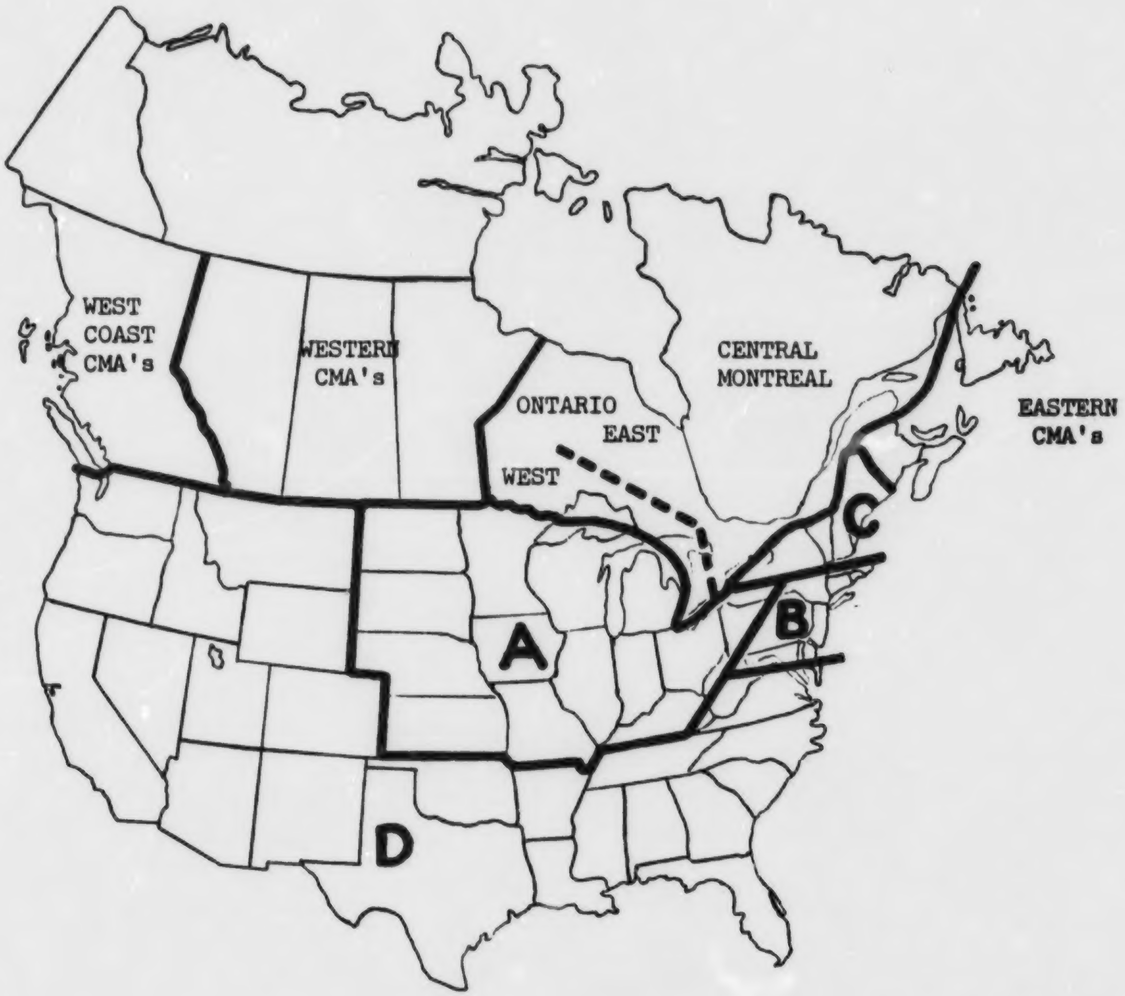


Figure 7

MARKET REGIONS

West Ontario contains those CMA's that must be served by air transshipment from Montreal but can be served by overnight truck delivery from other major air centers such as Detroit. The western CMA's must be served by air transshipment regardless of the major air center used. The West Coast CMA's, Vancouver and Victoria, were assumed to have direct transborder and European service; hence little or no cargo to/from these CMA's would move through Montreal. Region A is the Great Lakes region which is the major area for air movements from Montreal. Region B is the market area of the Northeast corridor, dominated by New York. Region C is the market area which can be served by overnight truck delivery from Montreal. Region D is the rest of the U.S. -- in which Montreal has no direct advantage. Regions A and C are the areas with greatest potential for a Montreal gateway.

At the present time Canadian North Atlantic cargo accounts for about 12 to 13 per cent of total North Atlantic traffic; only about 7 per cent of eastbound cargo is of Canadian origin, and slightly more than 17 per cent of westbound cargo moves to Canadian destinations. The bulk of the Canadian share moves via Montreal. As cargo volume grows, Montreal will continue to be the main North Atlantic center for this cargo -- unless Toronto is "opened" as a North Atlantic gateway for foreign airlines.

North Atlantic cargo

The North Atlantic cargo will be carried in some mix of air freighter and passenger aircraft. We believe air freighters will serve only major air centers. Air cargo will be transshipped between the air center and the originating/terminating CMA or SMSA. The transshipment will usually be performed by truck, occasionally by aircraft. We made the assumption concerning air centers for two reasons. First, the cargo to or from a European area (a small subset of Europe) must be consolidated in order to provide sufficient air cargo for an air freighter at service frequencies acceptable to the user of air cargo transport. Second, air centers, with their high throughput, will have lower cargo-handling costs.

An analysis of historical air cargo data in Appendix E and of the cargo forecasts in Appendix C shows that the markets in Regions A, B and C of Figure 7 can be served by five U.S. air centers. They are New York, Chicago, Detroit, Kansas City and Minneapolis/St. Paul. These centers were selected on the basis of their past and future demands for air cargo service and the fact that all remaining SMSA's in Regions A, B and C can be served from one of the five by overnight truck service, thereby providing adequate cargo transit time. Initially, we assumed that Montreal would be the major air center for eastern Canada.

If we were to assume that air cargo would be routed to the closest air center and then trucked to the CMA and SMSA receiving the cargo, the CMA and SMSA would be allocated to the six air centers (including Montreal) being considered as shown in Table 14. We made the assignments indicated in Table 14 using our major air center assumption and they result in the minimum land transportation distance and hence the lowest cargo transit times. These major air centers would have sufficient cargo movements to/from Europe to guarantee adequate service frequency.

The assignments in Table 14 must be adjusted to reflect transportation costs. For example, Buffalo is 355 road miles from Detroit, 385 miles from Montreal and 375 miles from New York. On the basis of minimum

Table 14

PRELIMINARY TERMINAL ASSIGNMENTS
(Minimum Land Cost Basis)

Chicago

- Chicago
- Davenport
- Dubuque
- Evansville
- Indianapolis
- Louisville
- Milwaukee
- Springfield

Detroit

- Buffalo
- Charleston
- Cincinnati
- Cleveland
- Detroit
- Erie
- Grand Rapids
- Hamilton
- Kitchner
- London
- Pittsburgh
- Toledo
- Toronto
- Windsor

Kansas City

- Des Moines
- Kansas City
- Omaha
- St. Louis
- Wichita

Minneapolis

- Calgary
- Duluth
- Edmonton
- Fargo
- Minneapolis
- Regina
- Saskatoon
- Sioux City
- Vancouver
- Victoria
- Winnipeg

Montreal

- Charlottetown
- Halifax
- Montreal
- Ottawa
- Quebec City
- Saint John
- St. John's
- Syracuse

New York

- Albany
- Baltimore
- Boston
- Hartford
- New York
- Philadelphia
- Scranton

transit time, cargo to and from Buffalo should move via Detroit. The additional transit time from either Montreal or New York would be acceptable. Air transportation is about twice as expensive as truck transportation, ignoring terminal costs. Further, Montreal is closer to European cities than any of the other major air centers. For example, New York is 180 miles further from London than Montreal, and Detroit is 490 miles further. Assuming that an air freighter costs about $1,000 per hour in the air, has an average effective speed of about 500 miles per hour and an average payload of about 25 short tons, line-haul costs by air are $0.08 per ton-mile. Line-haul truck costs are about $0.05 per ton-mile for a lightly loaded truck. The CMA's and SMSA's can be reassigned to major air centers to minimize total line-haul transport costs using the above estimates, providing overnight truck delivery is still possible. This reassignment assumes that terminal handling costs and total delays (for congestion, customs, etc.) are the same for all the major centers.

We arbitrarily assumed that overnight truck delivery distance is 400 miles and reassigned CMA's and SMSA's to minimize line-haul transport costs. As a result of this analysis, the following air center assignments were changed.

CMA/SMSA	Original Assignment	Revised Assignment
Albany	New York	Montreal
Boston	New York	Montreal
Buffalo	New York	Montreal
Des Moines	Kansas City	Chicago
Hamilton	Detroit	Montreal
Hartford	New York	Montreal
Indianapolis	Chicago	Detroit
Louisville	Chicago	Detroit

CMA/SMSA	Original Assignment	Revised Assignment
Milwaukee	Chicago	Detroit
Pittsburgh	Detroit	New York
St. Louis	Kansas City	Chicago
Scranton	New York	Montreal
Toronto	Detroit	Montreal

If we had assumed that the overnight truck distance was 300 miles, only Albany, Indianapolis and St. Louis would have been reassigned.

Airlines will generally use belly space on passenger aircraft to carry cargo and only introduce all-cargo aircraft when the passenger aircraft belly capacity has been exceeded. Therefore, it is necessary to analyze the future schedules of passenger aircraft over the North Atlantic route to determine the resulting belly cargo capacity. This analysis is described in Appendix E, and as a result of this analysis we conclude that the annual effective one-way belly capacity in 1975 will be distributed as follows:

	Thousands of Short Tons
New York	176
Montreal	44
Chicago	30
Detroit	8
All others	45

We have assumed that passenger aircraft will be able to average about 50 per cent utilization and this assumption is incorporated in the definition of effective one-way capacity. The "other" locations are the West Coast of North America and cities such as Dallas and Atlanta.

If we repeat the reassignment analysis using passenger aircraft costs instead of air freighter costs, all the reassignments stated above would occur except those for Hartford, Milwaukee and Scranton. Since the passenger aircraft belly capacities above indicate that Chicago and New York will have substantial belly capacity in 1975, we decided not to reassign these SMSA's.

Once again these reassignments assume that cargo-handling costs and delays due to customs are the same at all major air centers. The cargo-handling costs at Montreal, both air freighter and passenger, will be at least $4.00 per ton lower than New York costs and probably lower than costs at other U.S. air centers. These cost relationships serve to strengthen the assignment of the CMA's and SMSA's to Montreal. Since all CMA's and SMSA's within a 400-mile radius of Montreal have been assigned to Montreal (except Hartford), no other reassignments are possible as a result of differences in cargo-handling costs.

European cargo to and from Calgary, Edmonton, Regina, Saskatoon and Winnipeg will probably be transshipped at one of the major air centers because these CMA's cannot be served by overnight truck delivery from any of the air centers shown in Table 14. At the present time these CMA's, with the exception of Winnipeg, do not have any direct air service from Chicago, Detroit, Kansas City or Minneapolis/St. Paul. Therefore, we have reassigned these CMA's to Montreal. Winnipeg does have direct service from Chicago, but since the Winnipeg cargo must be transshipped, we felt that the cargo will probably move through Montreal. We also assumed that Vancouver will continue to have direct service to Europe and therefore the Vancouver and Victoria cargo will probably not move through any of the air centers shown in Table 14.

We have assumed that European cargo to and from CMA's east of Quebec City will not move through Montreal because of the cost of "back hauling" to Montreal. This assumption implies that the cargo to and from these CMA's will be served by aircraft also serving one of the major North American air centers. In any event, the European cargo to and from the eastern CMA's is only about 6 per cent of the tonnage that we believe will move through Montreal.

The revised terminal assignments and the 1975 and 1985 forecasts appear in Tables 15 and 16 respectively. These assignments provide adequate service frequency (because of the use of major air centers), acceptable transit time (less than 400 miles between CMA or SMSA and major air center) and minimum line-haul and cargo handling costs.

Actually, the minimum line-haul costs were developed by comparing like services -- for example freighter aircraft in Montreal versus freighter aircraft via the alternative gateway. No changes in the CMA's and SMSA's assigned to Montreal are required when the line-haul costs of serving the CMA or SMSA by air freighter via Montreal are compared with the costs of serving the CMA or SMSA by passenger aircraft via an alternative gateway.

If we were to ignore the differences in air line-haul cost under the assumption that the distances between Montreal and European cities are the same as the distances between New York and European cities because of air traffic routing, then the cargo-handling costs and truck line-haul costs will determine the assignments to major air centers that will define the minimum transportation cost systems. We stated above that the Montreal

Table 15

TERMINAL ALLOCATION - 1975

UNITED STATES AND CANADA/EUROPE*
(Short Tons)

	Import Forecasts			Export Forecasts		
	Low	Average	High	Low	Average	High
Chicago:						
Chicago	16,000	17,700	19,200	27,400	30,600	33,100
Davenport	1,800	2,000	2,200	3,000	3,400	3,600
Des Moines	1,200	1,300	1,400	300	400	400
Dubuque	900	1,000	1,100	1,400	1,600	1,700
Evansville	900	1,000	1,000	500	500	600
Milwaukee	6,800	7,500	8,200	10,600	11,900	12,800
St. Louis	5,800	6,400	7,000	2,100	2,300	2,500
Springfield	1,700	1,800	2,000	8,600	9,700	10,400
Total	35,100	38,700	42,100	53,900	60,400	65,100
Detroit:						
Charleston	2,000	2,200	2,400	3,300	3,600	3,900
Cincinnati	7,200	8,000	8,700	10,700	11,900	12,800
Cleveland	7,700	8,600	9,300	17,400	19,500	21,000
Detroit	10,500	11,700	12,700	23,900	26,700	28,800
Erie	500	600	600	1,800	2,000	2,100
Grand Rapids	2,400	2,700	3,000	2,000	2,200	2,400
Indianapolis	4,100	4,500	4,900	5,200	5,800	6,200
Kitchener	1,100	1,200	1,400	900	1,200	1,500
London	1,100	1,300	1,500	600	800	1,100
Louisville	3,600	4,000	4,300	3,700	4,200	4,500
Toledo	2,400	2,600	2,900	5,500	6,200	6,700
Windsor	1,100	1,200	1,400	1,400	1,900	2,400
Total	43,700	48,600	53,100	76,400	86,000	93,400
Kansas City:						
Kansas City	4,500	5,000	5,400	1,100	1,200	1,300
Omaha	2,700	3,000	3,200	500	600	700
Wichita	1,100	1,200	1,300	2,300	2,500	2,700
Total	8,300	9,200	9,900	3,900	4,300	4,700

* Minimum-cost basis.

Table 15, continued

	Import Forecasts			Export Forecasts		
	Low	Average	High	Low	Average	High
Minneapolis/St. Paul:						
Duluth	700	700	800	--	--	--
Fargo	1,000	1,100	1,200	--	--	--
Minneapolis/St. Paul	5,400	6,000	6,500	3,300	3,600	3,900
Sioux City	1,300	1,500	1,600	200	200	200
Total	8,400	9,300	10,100	3,500	3,800	4,100
Montreal:						
Albany	2,400	2,600	2,900	4,100	4,600	4,900
Boston	9,800	11,000	11,800	11,000	12,200	13,200
Buffalo	3,700	4,100	4,500	11,300	12,600	13,600
Calgary	2,000	2,200	2,500	400	500	600
Edmonton	2,200	2,500	2,900	500	700	800
Hamilton	2,400	2,700	3,100	2,100	2,900	3,700
Montreal	13,500	15,200	17,400	6,100	8,100	10,400
Ottawa	2,700	3,000	3,400	400	600	800
Quebec City	2,300	2,500	2,900	500	700	800
Regina	1,200	1,300	1,500	100	100	200
Saskatoon	1,200	1,300	1,500	100	100	200
Syracuse	1,700	1,900	2,100	3,400	3,800	4,100
Toronto	12,000	13,500	15,400	7,600	10,000	12,900
Winnipeg	2,500	2,800	3,200	600	700	900
Total	59,600	66,600	75,100	48,200	57,600	67,100
New York:						
Baltimore	10,900	12,100	13,200	6,100	6,800	7,300
Hartford	2,700	3,000	3,300	4,300	4,800	5,100
New York	31,200	34,700	37,700	34,900	39,000	42,100
Pittsburgh	5,900	6,500	7,100	8,200	9,200	9,900
Philadelphia	12,800	14,200	15,400	16,800	18,800	20,300
Scranton	1,400	1,600	1,700	900	1,000	1,100
Total	64,900	72,100	78,400	71,200	79,600	85,800

Table 16

TERMINAL ALLOCATION - 1985

UNITED STATES AND CANADA/EUROPE*
(Short Tons)

	Import Forecasts			Export Forecasts		
	Low	Average	High	Low	Average	High
Chicago:						
Chicago	33,500	44,300	59,100	59,600	79,000	100,700
Davenport	3,700	4,900	6,600	6,600	8,700	11,100
Des Moines	2,300	3,000	4,000	700	900	1,200
Dubuque	1,800	2,400	3,200	3,100	4,100	5,200
Evansville	1,600	2,100	2,800	1,000	1,400	1,800
Milwaukee	15,500	20,600	27,400	23,100	30,600	39,000
St. Louis	11,900	15,800	21,000	4,600	6,100	7,700
Springfield	3,300	4,400	5,900	18,800	24,900	31,800
Total	73,600	97,500	130,000	117,500	155,700	198,500
Detroit:						
Charleston	3,500	4,700	6,200	7,100	9,400	11,900
Cincinnati	14,500	19,200	25,600	23,200	30,700	39,200
Cleveland	15,500	20,500	27,300	37,900	50,200	64,100
Detroit	21,100	27,900	37,200	52,000	68,900	87,900
Erie	900	1,300	1,700	3,800	5,100	6,500
Grand Rapids	5,100	6,800	9,100	4,300	5,700	7,300
Indianapolis	8,400	11,100	14,800	11,300	14,900	19,000
Kitchener	2,200	3,000	3,400	2,000	3,200	4,800
London	1,900	2,600	2,900	1,400	2,200	3,300
Louisville	7,300	9,700	12,900	8,200	10,800	13,800
Toledo	4,700	6,200	8,300	12,000	15,900	20,300
Windsor	1,800	2,400	2,800	3,100	5,000	7,600
Total	86,900	115,400	152,200	166,300	222,000	285,700
Kansas City:						
Kansas City	9,300	12,300	16,400	2,400	3,200	4,100
Omaha	5,900	7,800	10,300	1,200	1,600	2,000
Wichita	2,100	2,800	3,700	4,900	6,500	8,300
Total	17,300	22,900	30,400	8,500	11,300	14,400

* Minimum-cost basis.

Table 16, continued

	Import Forecasts			Export Forecasts		
	Low	Average	High	Low	Average	High
Minneapolis/St.Paul						
Duluth	1,200	1,600	2,100	--	--	--
Fargo	2,000	2,600	3,500	100	100	100
Minneapolis/St.Paul	11,600	15,400	20,500	7,100	9,400	12,000
Sioux City	2,300	3,100	4,100	400	600	700
Total	17,100	22,700	30,200	7,600	10,100	12,800
Montreal:						
Albany	5,600	7,400	9,800	8,800	11,700	14,900
Boston	19,800	26,000	38,800	23,800	31,600	40,200
Buffalo	7,300	9,700	12,900	24,600	32,500	41,500
Calgary	3,700	5,000	5,700	800	1,300	2,000
Edmonton	4,000	5,400	6,200	1,100	1,800	2,700
Hamilton	4,300	5,800	6,700	4,700	7,600	11,500
Montreal	23,700	32,000	36,800	12,300	19,800	30,200
Ottawa	4,800	6,500	7,500	1,000	1,600	2,400
Quebec City	3,900	5,300	6,100	1,000	1,600	2,400
Regina	1,800	2,400	2,800	200	300	500
Saskatoon	1,900	2,600	3,000	200	300	500
Syracuse	3,700	4,900	6,600	7,400	9,800	12,500
Toronto	22,800	30,800	35,400	16,600	26,700	40,700
Winnipeg	3,900	5,300	6,100	1,100	1,700	2,600
Total	111,200	149,100	184,400	103,600	148,300	204,600
New York:						
Baltimore	23,100	30,600	40,700	13,300	17,600	22,400
Hartford	6,000	8,000	10,600	9,300	12,300	15,700
New York	63,100	83,500	111,400	75,900	100,600	128,200
Pittsburgh	10,900	14,400	19,200	18,000	23,800	30,300
Philadelphia	26,500	35,100	46,800	36,600	48,500	61,800
Scranton	2,500	3,300	4,400	2,000	2,700	3,400
Total	132,100	174,900	233,100	155,100	205,500	261,800

cargo-handling costs will be at least $4.00 per ton lower than the costs at New York and we expect the costs are more likely $7.00-$10.00 per ton lower. With these types of cost differences Albany, Buffalo and Syracuse can be served more economically via Montreal than any other gateway. Boston can be served from either Montreal or New York at about the same cost. If the cargo-handling costs in Montreal are about $6.00 per ton lower than Detroit's, the Toronto cargo will move via Montreal even assuming the air line-haul costs are the same via Montreal as via Detroit. Similarly, if the cargo-handling costs at Montreal are about $10.00 per ton lower than Detroit's, the Hamilton cargo will move through Montreal. Therefore, with the possible exception of Boston, Montreal's market in Tables 15 and 16 appears reasonable on a minimum-cost basis and ignoring delays.

We have not considered delays, the effect of congestion, the problems of customs clearances, or the competitive reactions by airlines in the analysis so far.

Montreal can certainly expect to capture the European air cargo to and from the Canadian CMA's assigned to Montreal in Table 15 and 16 and we have these CMA's as Montreal's "prime" markets. These CMA's will receive minimum-cost service with good service frequency and acceptable transit times by using the new airport at Montreal.

Additionally, Montreal could capture European cargo to and from U.S. SMSA's through aggressive marketing and by providing better service than other air centers. Albany, Buffalo and Syracuse would use Montreal if the problems of customs and the delays at border crossings, etc. can be solved.

Syracuse, for example, has no customs center -- international cargo arriving by air must be brought to a center, say Ogdensburg, to be cleared, thereby increasing delays and transit time. We talked to U.S. customs and they suggested the problem could be easily solved by providing a customs center at the Montreal airport and providing bonded truck transportation to the U.S. border. The impediments imposed by customs, border crossings, etc. are countered by the congestion in the New York area (in the air and on land). We believe that Montreal can solve the customs and delay problems through negotiations with the government and trucklines, and hence Albany, Buffalo and Syracuse form the first level of market penetration below the prime market.

If Montreal mounted an aggressive marketing campaign, we believe it could capture about half of the Boston tonnage on the grounds that the overall transportation costs via Montreal will probably be lower than service via New York. Boston has some direct service and the balance of the air cargo will move directly as belly cargo on passenger aircraft. Montreal's marketing campaign for Boston cargo will have to counter the natural reaction of the airlines serving Boston to divert the cargo to New York in order to keep the cargo on their own aircraft. An aggressive marketing campaign may also result in cargo to and from Cincinnati, Cleveland, Erie, Kitchener, London and Windsor moving through Montreal. These CMA's and SMSA's have been assigned to Detroit in Tables 15 and 16 and will require transshipment by air. Montreal may be able to capture this cargo because Montreal will be providing more frequent service to Europe than Detroit. We have designated these seven CMA's and SMSA's as the "second level" of market penetration.

Syracuse, for example, has no customs center -- international cargo arriving by air must be brought to a center, say Ogdensburg, to be cleared, thereby increasing delays and transit time. We talked to U.S. customs and they suggested the problem could be easily solved by providing a customs center at the Montreal airport and providing bonded truck transportation to the U.S. border. The impediments imposed by customs, border crossings, etc. are countered by the congestion in the New York area (in the air and on land). We believe that Montreal can solve the customs and delay problems through negotiations with the government and trucklines, and hence Albany, Buffalo and Syracuse form the first level of market penetration below the prime market.

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The situation at Minneapolis is somewhat different. The total anticipated tonnages in 1975 are rather low and the center will not have any significant direct European service in 1975 by either passenger or cargo aircraft. Minneapolis will be served primarily via one or more of the other centers at least until 1978-1980. At the present time service via New York predominates for North Atlantic cargo and probably via Chicago for domestic and transborder cargo. Service between Minneapolis and Montreal is poor at the present time. By 1985 Minneapolis will have some direct North Atlantic passenger service and perhaps some cargo service. These will be justified by their market size (see Table 16) and perhaps by the continuing availability of today's conventional jet aircraft or their service equivalents. Minneapolis is, in a sense, an isolated region and can be served at about the same level by New York, Chicago and Montreal. Montreal has the advantage of a lower terminal operating cost and a smaller total air distance, particularly for foreign airlines which do not serve Chicago, and less congestion. It has the disadvantage of infrequent indirect passenger aircraft connections to Minneapolis. This can be overcome by direct all-cargo services from Montreal.

Within the Chicago market area, Milwaukee is a large market which may not justify direct North Atlantic passenger service because of its proximity to Chicago. (Philadelphia, on the other hand, will have direct passenger service despite its proximity to New York because of its large population base.) It can, however, be served via Montreal at a competitive cost by those airlines which do not have North Atlantic entry rights into Chicago and by other airlines if Chicago's congestion approaches that of New York.

Pittsburgh is barely within the truck delivery zone of the New York air center and offers a potential market for Montreal for service by air. At the present time Montreal has good passenger service to Pittsburgh (six flights per day). The estimated cargo volumes are too large to be handled by passenger aircraft only and all-cargo service is indicated. For this market Montreal will be a more attractive exchange point than New York unless and until New York can overcome its congestion problems. Therefore, we have assumed that all cargo moving through the Minneapolis air center (Tables 15 and 16) and through Milwaukee and Pittsburgh constitute the third-level penetration for Montreal.

The 1975 and 1985 European air cargo volumes for the prime, first, second and third levels of market penetration appear in Tables 17 and 18, respectively, assuming that Toronto is not a major air center for European cargo. The reader must remember that these are estimates of Montreal penetration if the entire group of SMSA's and CMA's move their cargo via Montreal. This will never be the case because of existing traffic rights of airlines, transfer agreements between airlines, shipper's choice of carrier and route, the split between passenger and all-cargo aircraft, and the carrier's preference for exchange locations. On the other hand, we do not imply that traffic for other SMSA's and CMA's will not move through Montreal. Montreal now receives some cargo from Chicago, Detroit and other cities because the same forces and preferences are active. As an example, Air Canada can attract cargo for Chicago, Detroit and Los Angeles areas because of its route pattern -- and Montreal is a logical location for cargo interchange. Air Canada routes provide an entry via Montreal for

Table 17

1975 MONTREAL MARKET PENETRATION POTENTIAL
NORTH ATLANTIC SERVICE

Without Toronto As Major Air Center
(Short Tons)

Forecast	Imports			Exports		
	Low	Average	High	Low	Average	High
Prime:						
Calgary	2,000	2,200	2,500	400	500	600
Edmonton	2,200	2,500	2,900	500	600	800
Hamilton	2,400	2,700	3,100	2,100	2,900	3,700
Montreal	13,500	15,200	17,400	6,100	8,100	10,400
Ottawa	2,700	3,000	3,400	400	600	800
Quebec City	2,300	2,600	2,900	500	700	800
Regina	1,200	1,300	1,500	100	100	200
Saskatoon	1,200	1,300	1,500	100	100	200
Toronto	12,000	13,500	15,400	7,600	10,100	12,900
Winnipeg	2,500	2,800	3,200	600	700	900
Subtotal	42,000	47,100	53,800	18,400	24,400	31,300
1st level:						
Albany	2,400	2,600	2,900	4,100	4,600	4,900
Buffalo	3,700	4,200	4,500	11,300	12,600	13,600
Syracuse	1,700	1,900	2,100	3,400	3,800	4,100
Subtotal	7,800	8,700	9,500	18,800	21,000	22,600
2nd level:						
Boston (1/2)	4,900	5,500	5,900	5,500	6,100	6,600
Cincinnati	7,200	8,000	8,700	10,600	11,900	12,900
Cleveland	7,700	8,600	9,300	17,400	19,500	21,000
Erie	500	500	600	1,800	2,000	2,100
Kitchener	1,100	1,200	1,400	900	1,200	1,500
London	1,100	1,300	1,500	600	800	1,100
Windsor	1,100	1,200	1,400	1,400	1,900	2,400
Subtotal	23,600	26,300	28,800	38,200	43,400	47,600
3rd level:						
Milwaukee	3,400	3,800	4,100	5,300	5,900	6,400
Minneapolis/St. Paul area	8,400	9,300	10,100	3,500	3,900	4,200
Pittsburgh	5,900	6,500	7,100	8,200	9,200	9,900
Subtotal	17,700	19,600	21,300	17,000	19,000	20,500
Cumulative totals:						
Prime	42,000	47,100	53,800	18,400	24,400	31,300
Prime + 1	49,800	55,800	63,300	37,200	45,400	53,900
Prime + 1 + 2	73,400	82,100	92,100	75,400	88,800	101,500
Prime + 1 + 2 + 3	91,100	101,700	113,400	92,400	107,800	122,000

Table 15

1985 MONTREAL MARKET PENETRATION POTENTIAL
NORTH ATLANTIC SERVICE
Without Toronto As Major Air Center
(Short Tons)

Forecast	Imports			Exports		
	Low	Average	High	Low	Average	High
Prime:						
Calgary	3,700	5,000	5,700	800	1,300	2,000
Edmonton	4,000	5,400	6,200	1,100	1,800	2,700
Hamilton	4,300	5,800	6,700	4,700	7,600	11,300
Montreal	23,700	32,000	36,800	12,300	19,800	30,200
Ottawa	4,800	6,600	7,500	1,000	1,600	2,400
Quebec City	3,900	5,300	6,100	1,000	1,600	2,400
Regina	1,800	2,400	2,800	200	300	500
Saskatoon	1,900	2,600	3,000	200	300	500
Toronto	22,800	30,800	35,400	16,600	26,700	40,700
Winnipeg	3,900	5,300	6,100	1,000	1,700	2,600
Subtotal	74,800	101,200	116,300	38,900	62,700	95,300
1st level:						
Albany	5,600	7,400	9,800	8,800	11,700	15,000
Buffalo	7,300	9,700	12,900	24,600	32,600	41,500
Syracuse	3,700	4,900	6,600	7,400	9,800	12,500
Subtotal	16,600	22,000	29,300	40,800	54,100	69,000
2nd level:						
Boston (½)	9,900	13,000	17,400	11,900	15,800	20,100
Cincinnati	14,500	19,200	25,600	23,200	30,700	39,200
Cleveland	15,500	20,500	27,300	37,900	50,200	64,100
Erie	1,000	1,300	1,700	3,800	5,100	6,500
Kitchener	2,200	3,000	3,400	2,000	3,200	4,800
London	1,900	2,600	2,900	1,400	2,200	3,300
Windsor	1,800	2,400	2,800	3,100	5,000	7,600
Subtotal	46,800	62,000	81,100	83,300	112,200	145,600
3rd level:						
Milwaukee	7,800	10,300	13,700	11,600	15,300	19,500
Minneapolis/St. Paul area	17,100	22,700	30,200	7,600	10,100	12,900
Pittsburg	10,900	14,400	19,200	18,000	23,800	30,300
Subtotal	35,800	47,400	63,100	37,200	49,200	62,700
Cumulative totals:						
Prime	74,800	101,200	116,300	38,900	62,700	95,300
Prime + 1	91,400	123,200	145,600	79,700	116,800	164,300
Prime + 1 + 2	138,200	185,200	226,700	163,000	229,000	309,900
Prime + 1 + 2 + 3	174,000	232,600	289,800	200,200	278,200	372,600

airlines which do not serve all these centers (for example, Swissair, Air Lingus, Air Iberia; airlines which probably now route any such traffic via New York).

We note again that there is a distinct difference in directional balance between Canadian and U.S. trade in the North Atlantic. Canada is a net importer of North Atlantic cargo and will probably remain so. The target area in the United States is a net exporter by air and will probably remain so. Thus American air cargo moving through Montreal will tend to balance the airport activity between imports and exports -- in fact, there is a strong possibility that the ultimate trade balance at Montreal will be one with exports exceeding imports.

In several other studies of U.S. Great Lakes and Canadian overseas maritime trade (for government agencies) Montreal emerged as a natural center for rehandling international cargo to and from the upper Midwest. Montreal's advantages were not so overwhelming as to preclude competition by U.S. East Coast ports. On the other hand, the aggressive marketing programs and flexible services offered by Canadian railroads and the shipping companies serving Canadian ports are such as to guarantee Canadian ports a share of U.S. international trade. Our studies indicate that large manufacturing organizations with knowledgable transportation and distribution staffs were more likely to use routes via Canada than smaller and less knowledgeable organizations.

We feel that the air cargo situation is similar to that of maritime cargo. Montreal has natural advantages and offers cost savings but these advantages are not of sufficient magnitude to guarantee that large volumes of U.S. air cargo will move via Montreal. Aggressive marketing activity, flexible services and pricing and regular and frequent flights to U.S. centers are essential. Canadian and European airlines will have to develop a level of cooperation as has been achieved by Canadian railroads and the shipping companies. While IATA regulations may limit the flexibility of pricing for shipments moving entirely by air, there is some freedom in pricing and service for air-truck movements (particularly where U.S. state borders are not crossed) and cost savings in terminal operations and trucking.

Under the assumptions that marketing programs and flexible services will be offered and that New York's facilities will not expand to meet the potential demand, we estimate that Montreal can capture tonnage equivalent to the prime market and the first two penetration levels in the period 1975-1976. This market will amount to 21 per cent of North Atlantic cargo in 1975 (as compared to Canada's 1970 share of 12.9 per cent). The estimated market will have a good directional balance and somewhat less than half the cargo will move in passenger aircraft. Thus we expect Montreal to handle 82,000 tons of North Atlantic imports and 89,000 tons of North Atlantic exports in 1975.

While the market is estimated in terms of a specific set of SMSA's, we do not imply that Montreal will capture all of the cargo from these SMSA's (and CMA's) or that cargo for other centers will not move via Montreal. As a rough estimate, Montreal can capture two-thirds of the cargo from the listed SMSA's and perhaps one-fifth of the cargo to and from the other SMSA's in the target region.

The data presented in Tables 17 and 18 assume that Toronto does not develop as a major air center for European air cargo. If Toronto does become a major center for European air cargo, the following changes in these tables will be required. Calgary, Edmonton, Regina, Saskatoon and Winnipeg cargo will be divided between Montreal and Toronto. Since Toronto and Montreal will be in competition for this cargo, we have arbitrarily assumed that Montreal would be able to capture half of these markets and we have downgraded their markets to the first level because of the competition. While Montreal could capture a portion of the European cargo to and from Hamilton, Toronto, Cleveland, Erie, Kitchener, London and Windsor, we believe the proportion will be small and hence assumed that these markets will be served via Toronto.

Montreal will still be able to capture the Albany, Syracuse and Boston markets on the basis of costs. Buffalo can be served by either Montreal or Toronto at about the same costs. Therefore, we assigned half of the Buffalo cargo to each airport because of the competition. Montreal will be in direct competition with Toronto for the Cincinnati, Milwaukee, Minneapolis/St. Paul and Pittsburgh markets. Therefore, we also assigned half of these markets to each Canadian airport.

Tables 19 and 20 present the 1975 and 1985 North Atlantic air cargo volume for the prime, first, second and third levels of market penetration assuming that Toronto becomes a major center for European cargo, competing with Montreal. Once again, we believe that Montreal can capture the prime market and the first two penetration levels by 1975

Table 19

1975 MONTREAL MARKET PENETRATION POTENTIAL
NORTH ATLANTIC SERVICE
With Toronto as Major Air Center
(Short Tons)

Forecast	Imports			Exports		
	Low	Average	High	Low	Average	Hig
Prime:						
Montreal	13,500	15,200	17,400	6,100	8,100	10,4
Ottawa	2,700	3,000	3,400	400	600	8
Quebec City	2,300	2,600	2,900	500	700	8
Subtotal	18,500	20,800	23,700	7,000	9,400	12,0
1st level:						
Albany	2,400	2,600	2,900	4,100	4,600	4,9
Buffalo (1/2)	1,800	2,100	2,200	5,600	6,300	6,8
Calgary (1/2)	1,000	1,100	1,200	200	200	3
Edmonton (1/2)	1,100	1,200	1,400	200	300	4
Regina (1/2)	600	600	800	100	100	1
Saskatoon (1/2)	600	600	800	100	100	1
Syracuse	1,700	1,900	2,100	3,400	3,800	4,1
Winnipeg (1/2)	1,200	1,400	1,600	300	400	4
Subtotal	10,400	11,500	13,000	14,000	15,800	17,1
2nd level:						
Boston (1/2)	4,900	5,500	5,900	5,500	6,100	6,6
Cincinnati (1/2)	3,600	4,000	4,400	5,300	6,000	6,4
Subtotal	8,500	9,500	10,300	10,800	12,100	13,0
3rd level:						
Milwaukee (1/2)	1,700	1,900	2,000	2,600	3,000	3,2
Minneapolis/St. Paul area (1/2)	4,200	4,600	5,000	1,800	2,000	2,1
Pittsburgh (1/2)	3,000	3,200	3,600	4,100	4,600	5,0
Subtotal	8,900	9,700	10,600	8,500	9,600	10,3
Cumulative totals:						
Prime	18,500	20,800	23,700	7,000	9,400	12,0
Prime + 1	28,900	32,300	36,700	21,000	25,200	29,1
Prime + 1 + 2	37,400	41,800	47,000	31,800	37,300	42,1
Prime + 1 + 2 + 3	46,300	51,500	57,600	40,300	46,900	52,4

Table 20

1985 MONTREAL MARKET PENETRATION POTENTIAL
NORTH ATLANTIC SERVICE
With Toronto as Major Air Center
(Short Tons)

Forecast	Imports			Exports		
	Low	Average	High	Low	Average	High
Prime:						
Montreal	23,700	32,000	36,800	12,300	19,800	30,200
Ottawa	4,800	6,600	7,500	1,000	1,600	2,400
Quebec City	3,900	5,300	6,100	1,000	1,600	2,400
Subtotal	32,400	43,900	50,400	14,300	23,000	35,000
1st level:						
Albany	5,600	7,400	9,800	8,800	11,700	15,000
Buffalo (1/2)	3,600	4,800	6,400	12,300	16,300	20,800
Calgary (1/2)	1,800	2,500	2,800	400	600	1,000
Edmonton (1/2)	2,000	2,700	3,100	600	900	1,400
Regina (1/2)	900	1,200	1,400	100	200	200
Saskatoon (1/2)	1,000	1,300	1,500	100	200	200
Syracuse (1/2)	3,700	4,900	6,600	7,400	9,800	12,500
Winnipeg (1/2)	2,000	2,600	3,000	500	800	1,300
Subtotal	20,600	27,400	34,600	30,200	40,500	52,400
2nd level:						
Boston (1/2)	9,900	13,000	17,400	11,900	15,800	20,100
Cincinnati (1/2)	7,200	9,600	12,800	11,600	15,400	19,600
Subtotal	17,100	22,600	30,200	23,500	31,200	39,700
3rd level:						
Milwaukee (1/2)	3,900	5,200	6,800	5,800	7,600	9,800
Minneapolis/St. Paul area (1/2)	8,600	11,400	15,100	3,800	5,000	6,400
Pittsburgh (1/2)	5,400	7,200	9,600	9,000	11,900	15,200
Subtotal	17,900	23,800	31,500	18,600	24,500	31,400
Cumulative totals:						
Prime	32,400	43,900	50,400	14,300	23,000	35,000
Prime + 1	53,000	71,300	85,000	44,500	63,500	87,400
Prime + 1 + 2	70,100	93,900	115,200	68,000	94,700	127,100
Prime + 1 + 2 + 3	88,000	117,700	146,700	86,600	119,200	158,500

through an aggressive marketing campaign. The European cargo moving through Montreal is about halved if Toronto develops as a major international airport, assuming penetration to the second level but that the overall balance between import and export movements remains.

Transborder traffic

To estimate Montreal's share of transborder air cargo, we worked from a matrix of cargo flows between U.S. SMSA's and Canadian CMA's developed in another study. In that study the U.S. was divided into 78 SMSA's which were assigned their own and their hinterlands' originations -- Canada was divided into 19 CMA's. To define this portion of cargo allocation and others, we have divided the United States into four regions as was shown in Figure 7.

We have assumed that air cargo from and to Regions A, B and D to the Montreal, Quebec and Ottawa CMA's will move via Montreal. Cargo for eastern Canada and the Maritime Provinces from the United States except Region B will also move via Montreal -- Region B will have direct service, bypassing Montreal. Cargo from the U.S. for Ontario, the Prairies and western Canada will move via other centers. The resulting cargo movements under these assumptions are given in Table 21. Montreal is expected to serve about 37 per cent of Canadian air imports from the U.S. and about 31 per cent of Canadian air exports to the U.S. in 1975. We have no data for 1969 for comparison; airport loading and unloading statistics do not differentiate origin or destination region of international cargoes. There are indications that Toronto now has a larger

Table 21

MONTREAL MARKET PENETRATION POTENTIAL - TRANSBORDER SERVICE
(Short Tons)

	U.S. to Canada			Canada to U.S.		
	Low	Average	High	Low	Average	High
1975						
Regions A, B, D/ Montreal	11,800	13,100	15,400	3,700	4,700	5,400
Regions A, B, D/ Quebec, Ottawa	4,300	4,800	5,600	600	700	800
Regions A, D/ Eastern CMA's	4,000	4,500	5,200	400	500	500
Region C/ Eastern CMA's	400	500	600	-	-	-
TOTAL	20,500	22,900	26,800	4,700	5,900	6,700
1985						
Regions A, B, D/ Montreal	25,500	33,300	47,000	9,300	16,600	25,000
Regions A, B, D/ Quebec, Ottawa	9,200	12,000	17,000	700	1,300	2,000
Regions A, D/ Eastern CMA's	8,800	11,400	16,100	900	1,600	2,300
Region C/ Eastern CMA's	1,000	1,300	1,800	100	100	200
TOTAL	44,500	58,000	81,900	11,000	19,600	29,500

share of transborder cargo movements than Montreal -- and that it will continue to maintain its leadership. Transborder tonnages to Montreal are considerably less than the Canada-Europe tonnages -- but in both trades Canada (and Montreal) is a net importer. For 1975 we estimate that the Montreal air center will receive 22,900 tons from the U.S. and send 5,900 tons to the U.S.

Domestic traffic

Our estimates of domestic activity at Montreal were developed in the previous section.

Summary

In the preceding sections of this chapter we developed a forecast of total cargo, air cargo and Montreal air cargo for the North Atlantic, transborder and domestic service. Table 22 summarizes these forecasts. The total cargo forecasts are for air cargo plus all surface cargo valued at $1.00 per pound or more. The air cargo forecasts are the average forecasts discussed above and the Montreal air cargo forecasts are based on the assumption that Toronto does not develop as a major airport for European air cargo.

The European air cargo market is the most important to Montreal as it could account for more than half of the total air cargo handled in Montreal. It will also require an aggressive sales and promotional effort to capture the tonnages shown in Table 22. We have divided the European

Table 22

CARGO FORECASTS
(Thousand Short Tons)

	1975 Forecast		1985 Forecast	
	Imports	Exports	Imports	Exports
European Service				
Total cargo	887	1,075	1,540	1,677
Air cargo	413	412	1,035	1,062
Montreal air cargo	82	89	185	229
Transborder Service				
Total cargo	880	296	1,683	610
Air cargo	59	19	150	68
Montreal air cargo	23	6	58	20
Domestic Service				
Total Montreal	635	1,175	1,073	1,987
Montreal air cargo	40	66	105	162
Total Montreal air cargo	145	161	348	411

market into four categories: the prime market and the first, second and third levels of market penetrations. The prime market is that tonnage which the new Montreal airport should capture by its mere existence. The third level of market penetration is that level which will require the most aggressive marketing campaign, and hence the probability of service is the smallest. The tonnages at each level (based on average air cargo forecasts) are:

	1975		1985	
	Imports	Exports	Imports	Exports
Prime	47,100	24,400	101,200	62,700
First level	8,700	21,000	22,000	54,100
Second level	26,300	43,400	62,000	112,200
Third level	19,600	19,000	47,400	49,200

The data in Table 22 assumes that Montreal is successful in penetrating to the second level. If Montreal is not successful in penetrating either the first or second levels, the European air cargo moving through Montreal will be cut almost in half compared to the data in Table 22. Furthermore, the balance between eastbound and westbound European cargo shown in Table 22 will be negated if Montreal does not succeed in penetration to the second level, thereby adversely affecting unit costs.

Montreal should be able to capture the transborder and domestic air cargoes shown in Table 22 by providing an efficient air cargo terminal and good (frequent) service.

Table 23 presents the division of the 1975 European air cargo between the major air centers and the amount of cargo that will be carried in passenger aircraft for two different assumptions concerning Montreal's market capture. Assuming that the "standard" all-cargo aircraft in 1975 is a DC-8-63F with 50 per cent utilization, 5 round trips per week and 50 weeks of operation per year, 17 aircraft will be required to move the European air cargo not carried on passenger flights. If Montreal captures only its prime market, only two all-cargo flights per week would be required to supplement the cargo capacity of the passenger flights. However, if Montreal is successful in penetrating to the second level, about 13 all-cargo flights per week will be required. These numbers of all-cargo flights assume that the entire capacity of the aircraft is devoted to Montreal cargo. Montreal will actually experience more cargo flights since some carriers will divide the capacity between Montreal and some other city such as Chicago.

It is interesting to note that the belly capacity from New York far exceeds the requirements for the "local" air cargo. New York, therefore, will be a major transshipment port, handling European air cargo from other U.S. cities such as Detroit or San Francisco. New York will have some all-cargo flights; but, if Montreal can penetrate to the second level, Montreal will probably have more all-cargo flights than New York.

The figures in Table 22 do not fully reflect the air cargo activity at the Montreal terminal. A portion of the European air cargo into Montreal is destined to U.S. SMSA's (and hence becomes outbound transborder cargo) and another portion will move to other CMA's by air (and

Table 23

CARRIAGE OF EUROPEAN AIR CARGO, 1975
(Thousand Short Tons)

Montreal Captures Prime Market Only

	Imports		Exports	
	Cargo	Belly Capacity	Cargo	Belly Capacity
Montreal	47	44	24	44
New York	92	176	113	176
Chicago	39	30	60	30
Detroit	40	8	76	8
All other	195	45	139	45
Total	413	303	412	303

Montreal Achieves Prime, First and Second Level Penetration

	Imports		Exports	
	Cargo	Belly Capacity	Cargo	Belly Capacity
Montreal	82	44	89	44
New York	78	176	86	176
Chicago	39	30	60	30
Detroit	19	8	38	8
All other	195	45	139	45
Total	413	303	412	303

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become outbound domestic cargo). This relationship holds for all imports and exports, and further analysis is required to determine the amount of cargo handled at the cargo terminal. Our estimate of domestic cargo at Montreal also includes cargo transferred from one air route to another, thus the same shipment appears as an inbound and as an outbound shipment.

The breakdown of all North Atlantic transborder and domestic movements and development of the estimates of cargo handled and cargo loaded and unloaded for 1975 and 1985 are presented in Tables 24 and 25, using the average forecast data and assuming that Toronto does not develop as a major air center for European air cargo. For each trade and direction we give the tonnage moving to or from the air center by truck and the tonnage moving through the air center from one aircraft to another. Air-to-air transfers thus appear in both the inbound and outbound columns.

In 1975, the Montreal air cargo center will have a unique throughput of 284,000 short tons of cargo, but cargo loaded on or unloaded off aircraft will be 366,200 tons -- that is, 82,300 short tons will have been doubled-handled, 97,400 tons of cargo will move from the Montreal air cargo center to local, domestic, and U.S. markets by truck, and 104,400 short tons will move to the terminal by truck. The estimated 1975 activity is more than a threefold increase over 1970 levels.

By 1985, the air cargo center's unique throughput will be 712,800 short tons, and 909,300 short tons will be loaded or unloaded from aircraft. Truck tonnages will rise to 229,000 tons from the airport to consignees and 286,400 tons from shippers to the airport.

Table 24

MONTREAL AIRPORT ACTIVITY, 1975
PRIME AND FIRST AND SECOND LEVELS
Without Toronto as a Major Air Center
(Thousand Short Tons)

	Activity Type	Inbound Tons	Outbound Tons
Canada to Europe	Air/air	5.9	5.9
	Truck/air		22.4
Europe to Canada	Air/air	13.8	13.8
	Air/truck	37.0	
Canada to U.S.			
Eastern CMA's	Air/air	0.5	0.5
	Air/truck	-	
Montreal, Quebec, Ottawa	Truck/air		5.4
U.S. to Canada			
Eastern CMA's	Air/air	4.5	4.5
	Truck/air		0.5
Montreal, Quebec, Ottawa	Air/truck	17.9	
U.S. to Europe	Air/air	33.4	33.4
	Truck/air		27.1
Europe to U.S.	Air/air	17.1	17.1
	Air/truck	14.2	
Canada to Canada (excluding international transshipments)	Air/air	7.0	7.0
	Air/truck	28.3	
	Truck/air		49.0
Total	Air/air	82.2	82.2
	Air/truck	97.4	
	Truck/air		104.4
Grand Total		179.6	186.6

Total tons loaded on or off aircraft* 366.2

Total tons moving through terminal* 284.0

*If domestic cargo moves through Dorval, the totals become:

Total tons loaded on or off aircraft 274.9

Total tons moving through terminal 199.7

Table 25

MONTREAL AIRPORT ACTIVITY, 1985
PRIME AND FIRST AND SECOND LEVELS
Without Toronto as a Major Air Center
(Thousand Short Tons)

	Activity Type	Inbound Tons	Outbound Tons
Canada to Europe	Air/air	15.8	15.8
	Truck/air		57.3
Europe to Canada	Air/air	28.7	28.7
	Air/truck	80.5	
Canada to U.S.			
Eastern CMA's	Air/air	1.6	1.6
	Air/truck	0.1	
Montreal, Quebec, Ottawa	Truck/air		17.9
U.S. to Canada			
Eastern CMA's	Air/air	11.4	11.4
	Truck/air		1.3
Montreal, Quebec, Ottawa	Air/truck	45.3	
U.S. to Europe	Air/air	86.0	86.0
	Truck/air		69.9
Europe to U.S.	Air/air	41.0	41.0
	Air/truck	35.0	
Canada to Canada*	Air/air	12.0	12.0
	Air/truck	69.0	
	Truck/air		140.0
Total	Air/air	196.5	196.5
	Air/truck	229.9	
	Truck/air		286.4
Grand total		426.4	482.9

Total tons loaded on or off aircraft	909.3
Total tons moving through terminal	712.8

* Excluding international transshipments.

The tonnages shown in Tables 24 and 25 are based on the assumption that no air cargo moves through Dorval. If air cargo continues to move through Dorval, the tonnages presented in Tables 24 and 25 must be reduced accordingly For example, if the domestic air cargo shown in the tables moves through Dorval, the tonnage loaded on or off aircarft and the tonnage moving through the terminal at Sainte Scholastique would be reduced to the values shown at the bottom of the tables.

The tonnages shown in Tables 24 and 25 are also based on the assumption that Montreal penetrates to the second level of market penetration on the European cargo. If Montreal only captures the prime European market, the tonnages must be revised accordingly (Table 26). The 1975 tonnages are a unique throughput of 184,600 short tons, 208,700 tons loaded and unloaded from aircraft, 83,200 tons delivered to consignees by truck and 77,300 tons delivered to the airport by truck from shippers. This estimated activity is twice the 1970 activity of the existing Montreal airport.

The data presented in Tables 24, 25 and 26 represent the activity at the Montreal airport assuming that Toronto does not develop as a major air center for European cargo. Should Toronto develop as an international airport, the North Atlantic cargo will be halved. Tables 27 and 28 present the forecast activity at the airport for the prime plus first and second levels of market penetration and the prime level only. It is interesting to note that the activity at Montreal, assuming prime market only and that Toronto is not a major international airport, is about the same as the activity assuming prime through second level market capture and that Toronto is a major international airport.

Table 26

MONTREAL AIRPORT ACTIVITY, 1975
PRIME MARKET ONLY
Without Toronto as a Major Air Center
(Thousand Short Tons)

	Activity Type	Inbound Tons	Outbound Tons
Canada to Europe	Air/air	2.0	2.0
	Truck/air		22.4
Europe to Canada	Air/air	10.1	10.1
	Air/truck	37.0	
Canada to U.S.			
Eastern CMA's	Air/air	0.5	0.5
	Air/truck	-	
Montreal, Quebec, Ottawa	Truck/air		5.4
U.S. to Canada			
Eastern CMA's	Air/air	4.5	4.5
	Truck/air		0.5
Montreal, Quebec, Ottawa	Air/truck	17.9	
U.S. to Europe		-	-
Europe to U.S.		-	-
Canada to Canada (excluding international transshipments)	Air/air	7.0	7.0
	Air/truck	28.3	
	Truck/air		49.0
Total	Air/air	24.1	24.1
	Air/truck	83.2	
	Truck/air		77.3
Grand Total		107.3	101.4

Total tons loaded on or off aircraft*	208.7
Total tons moving through terminal*	184.6

*If domestic cargo moves through Dorval, the totals become:

Total tons loaded on or off aircraft	117.4
Total tons moving through terminal	100.3

Table 27

MONTREAL AIRPORT ACTIVITY, 1975
PRIME AND FIRST AND SECOND LEVELS
With Toronto as a Major Air Center
(Thousand Short Tons)

	Activity Type	Inbound Tons	Outbound Tons
Canada to Europe	Air/air	1.1	1.1
	Truck/air		9.4
Europe to Canada	Air/air	4.9	4.9
	Air/truck	20.8	
Canada to U.S.			
Eastern CMA's	Air/air	0.5	0.5
	Air/truck	-	
Montreal, Quebec, Ottawa	Truck/air		5.4
U.S. to Canada			
Eastern CMA's	Air/air	4.5	4.5
	Truck/air		0.5
Montreal, Quebec, Ottawa	Air/truck	17.9	
U.S. to Europe	Air/air	6.0	6.0
	Truck/air		20.8
Europe to U.S.	Air/air	4.0	4.0
	Air/truck	12.1	
Canada to Canada (excluding international transshipments)	Air/air	7.0	7.0
	Air/truck	28.3	
	Truck/air		49.0
Total	Air/air	28.0	28.0
	Air/truck	79.1	
	Truck/air		85.1
Grand Total		107.1	113.1

Total tons loaded on or off aircraft*	220.2
Total tons moving through terminal*	192.2

*If domestic cargo moves through Dorval, the totals become:

Total tons loaded on or off aircraft	128.9
Total tons moving through terminal	107.9

Table 2b

MONTREAL AIRPORT ACTIVITY, 1975
PRIME MARKET ONLY
With Toronto as a Major Air Center
(Thousand Short Tons)

	Activity Type	Inbound Tons	Outbound Tons
Canada to Europe	Air/air	-	-
	Truck/air		9.4
Europe to Canada	Air/air	-	
	Air/truck	20.8	
Canada to U.S.			
Eastern CMA's	Air/air	0.5	0.5
	Air/truck	-	
Montreal, Quebec, Ottawa	Truck/air		5.4
U.S. to Canada			
Eastern CMA's	Air/air	4.5	4.5
	Truck/air		0.5
Montreal, Quebec, Ottawa	Air/truck	17.9	
U.S. to Europe	Air/air	-	-
	Truck/air		-
Europe to U.S.	Air/air	-	-
	Air/truck	-	
Canada to Canada (excluding international transshipments)	Air/air	7.0	7.0
	Air/truck	28.3	
	Truck/air		49.0
Total	Air/air	12.0	12.0
	Air/truck	67.0	
	Truck/air		64.3
Grand Total		79.0	76.3

Total tons loaded on or off aircraft* 155.3

Total tons moving through terminal* 143.3

*If domestic cargo moves through Dorval, the totals become:

Total tons loaded on or off aircraft 64.0

Total tons moving through terminal 59.0

III. AIR FREIGHT TERMINAL OPERATION

Task II of our assignment covers the planning and operating requirements on the air freight terminal for varying percentages of the air cargo market. In this chapter, we present a general plan for the terminal, describe its functions and the facilities required for carrying out the functions, discuss required operating procedures, and estimate costs. Where appropriate, we expand the discussion to include the impact of common-user versus proprietary terminals (or a combination).

The unique function of an air cargo terminal is the loading and unloading of aircraft, dictating the terminal's location (at the airport), and the requirements for certain specialized facilities. The special feature of aircraft in relation to cargo handling is that the acquisition cost of the aircraft per ton of cargo capacity ranges from $200,000 per ton and up. A simple contrast to a motor vehicle shows a range from $200 per ton for a highway semitrailer to $5,000 for a special pickup and delivery vehicle. The range for railroad cars might be from $400 per ton to $4,000. The extraordinarily high value for aircraft has the immediate consequence that the aircraft time value may dominate the costs of all other resources used in loading. The aircraft has a time value of about $300 to $400 per hour while at the loading dock, whereas the cost per hour for loading crew and the equipment used by the crew would total about $100 per hour.

Therefore, in planning a cargo terminal operation, the emphasis must be on substituting idle time of crew and equipment for idle time of aircraft (and minimizing the sum). This is not commonly the case in truck and rail freight operations, where the crew costs far exceed the time value of the equipment being loaded or unloaded.

A primary requirement in the planning of an air cargo terminal and its operations is the long- and short-range estimation of cargo throughputs. Long-range estimates are needed to develop plans for building, equipping, and staffing a terminal, and to make provisions for subsequent expansions. Short-run estimates are needed as inputs to the planning of work schedules, scheduling of the cargo functions, and carrying out the necessary functions so that the air cargo will be ready for the scheduled departure of the aircraft. Estimating procedures are also involved in the matching of aircraft arrival and departure schedules, and adjusting to variances from schedules to minimize delays caused by unplanned congestion.

This chapter is divided into discussions of the following subjects:

Terminal functions
Terminal facilities
Terminal procedures
Air cargo terminal costs
Feasibility analysis
Montreal terminal requirements
Montreal terminal costs
Summary

The first four subjects are general discussions set in the framework of the general air cargo facility layout being considered for the new

Montreal airport. The last three subjects pertain to the facility in the context of the air cargo market defined in the previous chapter.

Terminal Functions

The air cargo terminal functions may be classed as cargo-handling functions and information functions. These functions interact at several activities -- particularly where choices are made of the next cargo-handling function for a shipment. We will describe the cargo-handling functions, the information functions, and common-user functions.

Cargo-handling functions

For the purpose of this discussion, there are four types of air cargo: transit, transfer, inbound and outbound. Transit cargo is cargo unloaded from an aircraft in order to gain access to cargo stowed behind. Transit cargo is subsequently loaded onto the same aircraft. Transfer cargo is cargo unloaded from one aircraft and subsequently loaded onto another. Inbound cargo is unloaded from an aircraft and delivered to a land carrier while outbound cargo is received from a land carrier and loaded onto an outbound aircraft.

Air cargo can be moved in bulk (for example, nonunitized) or on pallets. "Pallets" in this discussion refers to pallets, igloos or containers that are loaded onto or from aircraft. Both passenger and all-cargo aircraft are capable of carrying pallets in this sense.

The principal cargo-handling functions that are performed on inbound cargo are: aircraft unloading (including delivery to the air cargo terminal), temporary storage (awaiting further processing) retrieval, separation, sorting, storage, retrieval, delivery (to land carrier) and loading onto land-carrier vehicle. The temporary storage, and the subsequent retrieval, is important when transit and transfer cargo is being handled and implies random access in order to minimize the possibility of delaying aircraft. A significant proportion of the cargo will arrive as mixed shipments on pallets. The pallet load must be separated and sorted into individual shipments and stored to await delivery to the land carrier when it will be retrieved for the second time. Once again, storage and retrieval implies random access.

Outbound cargo has the same basic functions only in reverse: unloading from the land carrier's vehicle, receive (including checking), store, retrieve, sort, unitize, store, retrieve and load aircraft (including delivery to the aircraft). The first storage is a temporary storage awaiting the completion of the paperwork or the arrival of cargo-handling equipment. Therefore, the truck dock or an area nearby must be capable of accommodating this temporary storage. In this case, random access is desired but not required. Sorting breaks down the land-carrier load into the proper flights and destinations and unitizing places the individual shipments onto the pallet (or bulk cart).

The air cargo terminal must provide all these services with the possible exception of truck loading and unloading. The terminal will be responsible for loading and unloading all-cargo aircraft but may not be responsible for unloading and loading passenger aircraft. While the terminal must provide these functions, individual shipments may bypass some of these functions. For example, loaded pallets may be delivered directly to the land carrier, thereby avoiding the separating and sorting functions. Other shipments may be expedited and avoid storage. Figure 8 graphically presents the basic variations of shipment handling. The transit cargo in Figure 8 is shown as avoiding the initial storage and retrieval functions. This is probably the case with bulk cargo in belly spaces or pallet cargo on passenger aircraft since the cargo may be merely "stored" on the ground near the aircraft until it is reloaded. However, transit pallet loads from the main deck of all-cargo aircraft will enter the terminal (actually the freighter dock) because of the unloading and loading equipment involved.

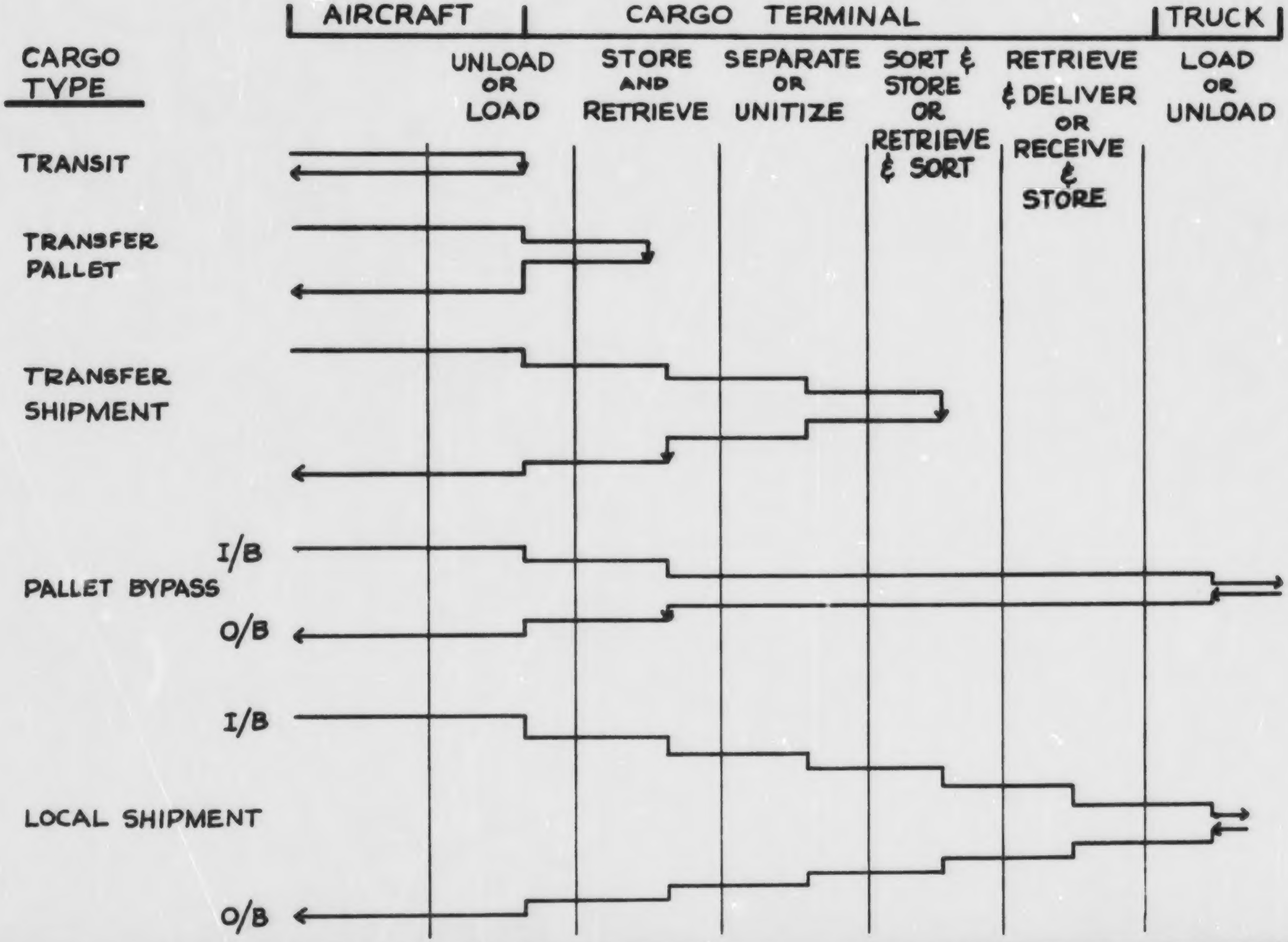
International shipments will require customs clearance. Part or all of a shipment may be physically retrieved and delivered to customs for appraisal and then returned to storage. These inspections are called for selectively by customs agents and usually for part of a shipment. From the carrier's point of view the shipments are selected by customs in a random manner.

Information handling

Information on inbound shipments includes data on a collection of shipments, such as aircraft arrival schedules, and the pending arrival of certain designated containers. In addition, data on the specific shipments within the containers and the aircraft must be received by the terminal operator for planning the handling and forwarding of the inbound shipment.

FIGURE - 8

VARIETIES OF SHIPMENT HANDLING



This information may, in fact, arrive with the freight on the same aircraft or it may be transmitted prior to the arrival of the aircraft over communication lines. If the information arrives after the aircraft because of communication delays, serious delays to shipments and aircraft may result.

Information on the location of a shipment must be maintained throughout the period from notice of the arriving shipment until and beyond the physical delivery of the shipment. These data are used for tracing shipments for customers, verifying shipment deliveries, and for advising terminal management that the cargo-handling functions are proceeding on schedule and shipments are not unduly delayed.

Special information handling is also required for inbound international shipments to be processed through customs. The notice of arrival must be forwarded to the agent who will arrange the clearance through customs, and the shipment must be held until the notice of customs clearance is returned to the operator.

Further information processing is related to transfer of responsibility for the shipment. Receipts must be issued for cargo received and secured for cargo dispatched. Shipment information on special handling must be received and transmitted to the cargo-handling staff in order to ensure that special instructions are followed for perishables, valuables, live animals, and other special cargo.

The first information received for an outbound shipment is usually a request from a shipper for cargo space in a particular flight. The carrier must be notified and space is then reserved for that shipper's cargo. The second item of information, which may or may not be presented at the same time as the cargo space booking, is the request for pickup. This information is forwarded to the truck operator who dispatches a truck for the cargo. There is no pickup request, however, if the shipper uses his own vehicles or his own hired carriers to deliver the cargo to the air freight terminal. The third piece of information is generated when the cargo is received from the truck. A receipt is issued (air waybill) for the cargo and a copy is marked with the flight number if space has been reserved. Some air carriers use the information on cargo on hand for a given flight to plan the loading of the containers for that flight. If each containerload is preplanned, the instructions on the selection of shipments from storage must be transmitted to the cargo handlers. After the shipments are loaded into units (pallets or bulk carts), the unit identification must be recorded on the waybill.

Information on unitized shipments, including total weight of the shipments unitized and the destination of the units, is processed by the aircraft load planners to determine the position of each unit in the loaded aircraft. This information is transmitted to the cargo handlers to allow the selection of units in the right order for loading on the aircraft.

The status of each outbound shipment must be controlled at all times as on inbound shipments. Status information is used for advising shippers and consignees, and for advising management of the expeditious movement of all shipments.

Finally, a manifest of the outbound shipments must be prepared for dispatch with the aircraft or dispatch by communication networks to the receiving station. The waybill information is transmitted to a local office or central office for rating and billing of charges, for summarizing and reporting of traffic statistics to management, to trade associations, and to local and national authorities as required.

The paperwork for the transfer function is extremely important. Failure of transfer stations to keep track of shipments and provide prompt information to the origin and destination stations is a major barrier to the development of transfer centers. On each transfer shipment, the transfer stations must notify both origin and destination stations of the forwarding of the shipment.

Other documentation on transfer shipments would be similar to the inbound and outbound shipments with respect to the allocation of space on outbound flights for transfer shipments, the notification of the load planners of the transfer shipments, the assignment by the load planners of transfer shipments to cargo units or belly compartments, and the recording of forwarding information for tracing and for notification purposes.

Common-user functions

A number of the cargo-handling functions can be operated as a common-user service, or jointly by a number of airlines. Each function offers opportunities for economies of scale directly or through the use of increased mechanization. Most airlines use such service at smaller domestic terminals or in overseas terminals where the host airline provides services for other carriers. In many cases airlines prefer to operate their own terminals to maintain control and to retain the airline's service image.

A common-user function in operation at many air cargo terminals (for example, Tokyo International) is a joint international inbound cargo facility. The special procedures for processing such cargo -- customs forms, availability for customs inspection, duty assessment and payment, import broker services -- and the potential for bonded storage and delayed customs clearance, are such that a single location is attractive both in terms of economics and reduction of delays. The airlines are not subject to the risks of delay or inefficient loading on inbound cargo, as they are on outbound cargo, and they are more amenable, therefore, to such common services. While such arrangements may be forced on the airlines in some overseas countries, we feel that a voluntary association based on the economic and service advantages is possible.

Another common function, at international airports at least, is the loading and unloading of freighter aircraft. A common apron/dock facility has the advantage of higher throughput per foot of high-priced apron space and a high enough dock utilization to allow economical mechanization and the attainment of high-speed handling and fast aircraft turnaround. Using a straightforward queue model we have found, for example, that a common-user freighter dock with four apron positions can give better service (slightly smaller average aircraft delay) than eight apron positions operated independently, even without any technical advantage attributed to the common-user freighter dock for more efficient mechanization.

A third common function is the filling and stripping of pallets and bulk carts. This function could be performed for some, if not all, air carriers who use the air cargo terminal. One can add to this the transport of pallets and bulk carts between the cargo terminal and the passenger terminal apron.

Lastly, we could consider all services except receipt and, perhaps, delivery of cargo (over the truck docks) as common, thus eliminating all cargo handling by the airlines except for the loading of passenger aircraft bellies with luggage, mail and cargo. A carrier can also choose to use an independent agent for paperwork and documentation functions, and at such locations is a cargo carrier only.

A common cargo facility and common freighter dock facility are of the greatest interest and have the greatest potential for most airlines and for the new Montreal airport. The capture of a share of the U.S.

North Atlantic cargo will require some common facilities for handling U.S. cargo in consolidated truckloads or aircraft transfer pallets, and special arrangements with both U.S. and Canadian customs. The common freighter dock offers opportunities for high utilization of facilities and low-cost cargo handling, which will aid in the development of Montreal as an air cargo center.

At the present time there is no operating common-user air cargo terminal at a major cargo center. At a few locations several air lines share a terminal, but it is operated by one airline which acts as agent for others (the others generally have a relatively low volume of activity at the center). At several major centers there is a joint activity for foreign imports. For example, at Tokyo (Haneda) all air cargo imports share a common customs clearance and in-transit facility, but the major international airlines operate their own facilities for export cargo. The new BOAC terminal at London (Heathrow) was intended as a common-user terminal, but the larger foreign airlines serving London maintain their own facilities.

At the Tokyo Airport arriving international cargo is temporarily consigned to IACT (International Airport Cargo Terminal Company) rather than to the carrier. Consignees receive documents from the air carrier but they take delivery from IACT. Outbound cargo from Tokyo clears export control under the custody of the airline or the forwarder -- IACT plays no role in outbound movements or in handling in-transit cargo.

In almost all cases in which extensive terminal automation has been attempted it has not been effective. Both KLM and BOAC have remanned a considerable part of the automatic equipment at Amsterdam (Schipol) and London respectively. The apparent failure of full automation has led some airlines to question the economies of scale of large operations. Our own analysis indicates that insofar as terminal handling costs alone are considered there is little saving at levels of over 150,000 tons a year.

Terminal Facilities

Air cargo terminal facilities have separate related areas for aircraft taxiways, aircraft parking apron, cargo handling, truck doors and truck parking, passenger car parking, and access streets.

Basic arrangements

The basic proposed plan reproduced* in Figure 9 for the east side occupies an area of about 2,000 feet by 2,000 feet. About 20 per cent of the area is reserved for cargo apron; the rest is divided into five building areas and related streets and parking. The five buildings are perpendicular to the cargo apron in their long direction.

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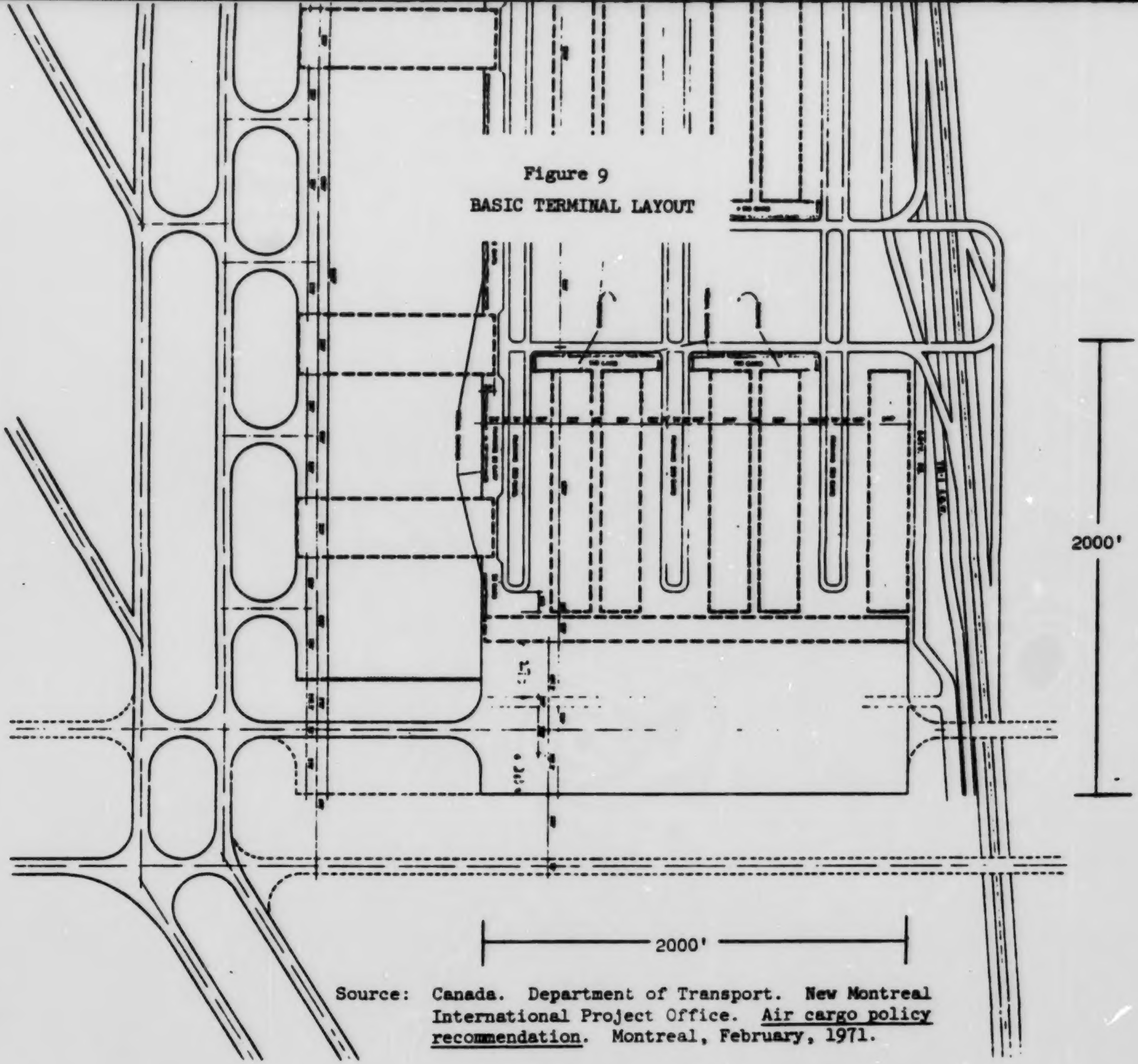
* From Drawing 82AX1135005 of BANAIM, "Cargo and Maintenance Area Alternative 7d (ultimate)," dated 29-9-70.

Figure 9

BASIC TERMINAL LAYOUT



Source: Canada. Department of Transport. New Montreal International Project Office. Air cargo policy recommendation. Montreal, February, 1971.

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In a revised version, which we were shown during our meetings in Montreal in March, the layout of the new cargo terminal facilities includes four rectangular buildings, 250 feet by 1,200 feet, a system of roadways connecting the buildings to off-airport traffic, an area for automobile parking and for truck parking, and a common-user facility for loading and unloading aircraft. This version corrects a number of flaws in the earlier version. Prior to learning about the revision, we developed a U-shaped building concept as an alternative to the earlier version. For the sake of a complete record, we present our concept in Figure 10, although our following discussion accepts the version with four rectangular buildings.

The revised plans call for 30-foot-wide access loop roads from the main spine road to the terminal buildings. We have portrayed the layout of these buildings and roadways, but with a 50-foot roadway instead of a 30-foot roadway, in Figure 11.

We have shown the flow of traffic in this roadway system as clockwise through the loop between the terminal buildings in Figure 12. Clockwise traffic allows the trucks and truck-trailer combinations to back into the terminals on the left-hand side, a safer maneuver for left-hand-drive vehicles. The trucks can turn left off the access loop road and enter through gates into the truck area opposite each terminal. They can then back into the receiving door. In leaving the truck area they would drive out from the door with a left turn and turn right onto the roadway through one of the openings, then follow around the loop until they reach the spine road.

FIGURE-10

TERMINAL PLAN VARIATION WITH U-SHAPED BUILDINGS

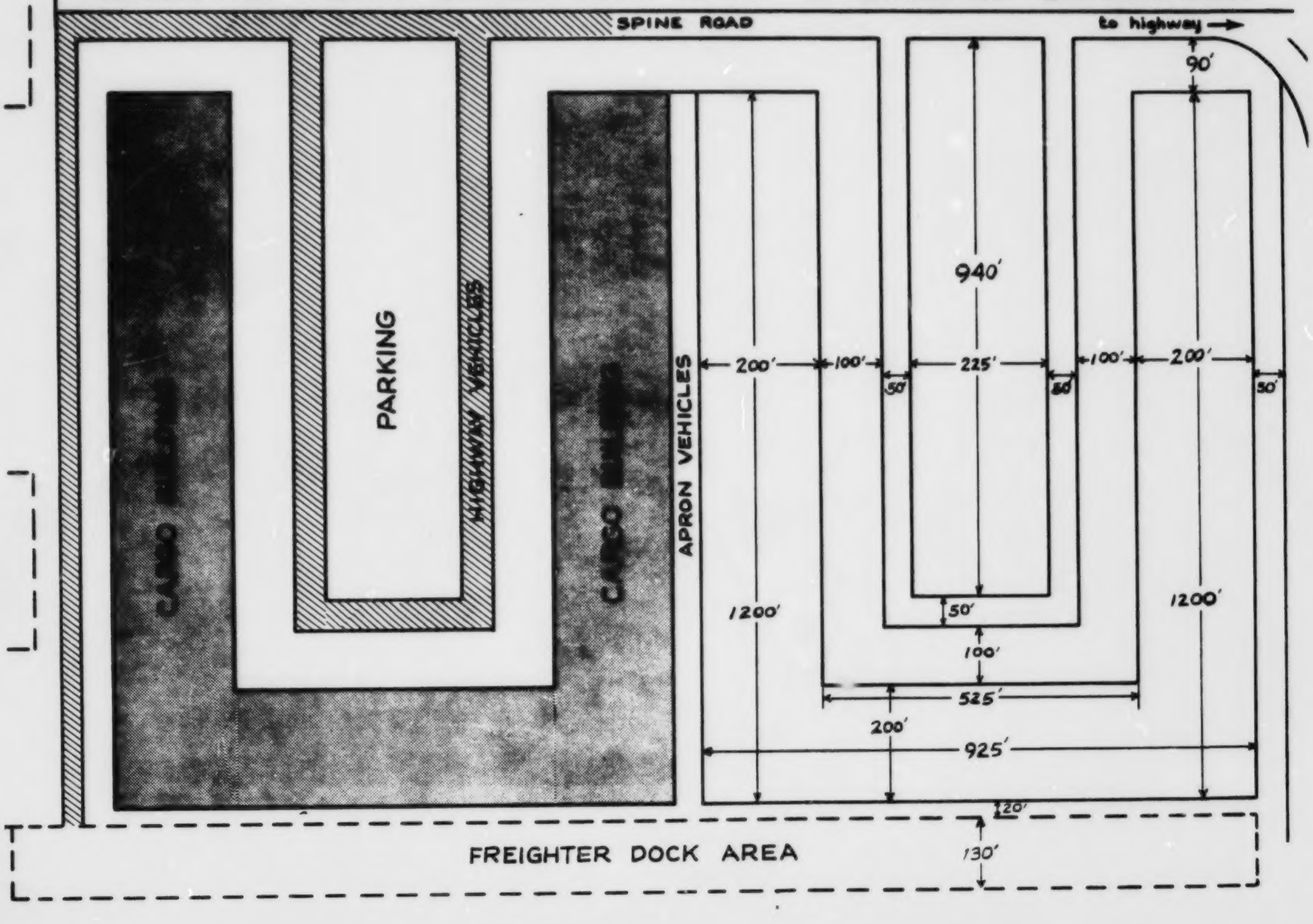


FIGURE - 11

REVISED TERMINAL LAYOUT

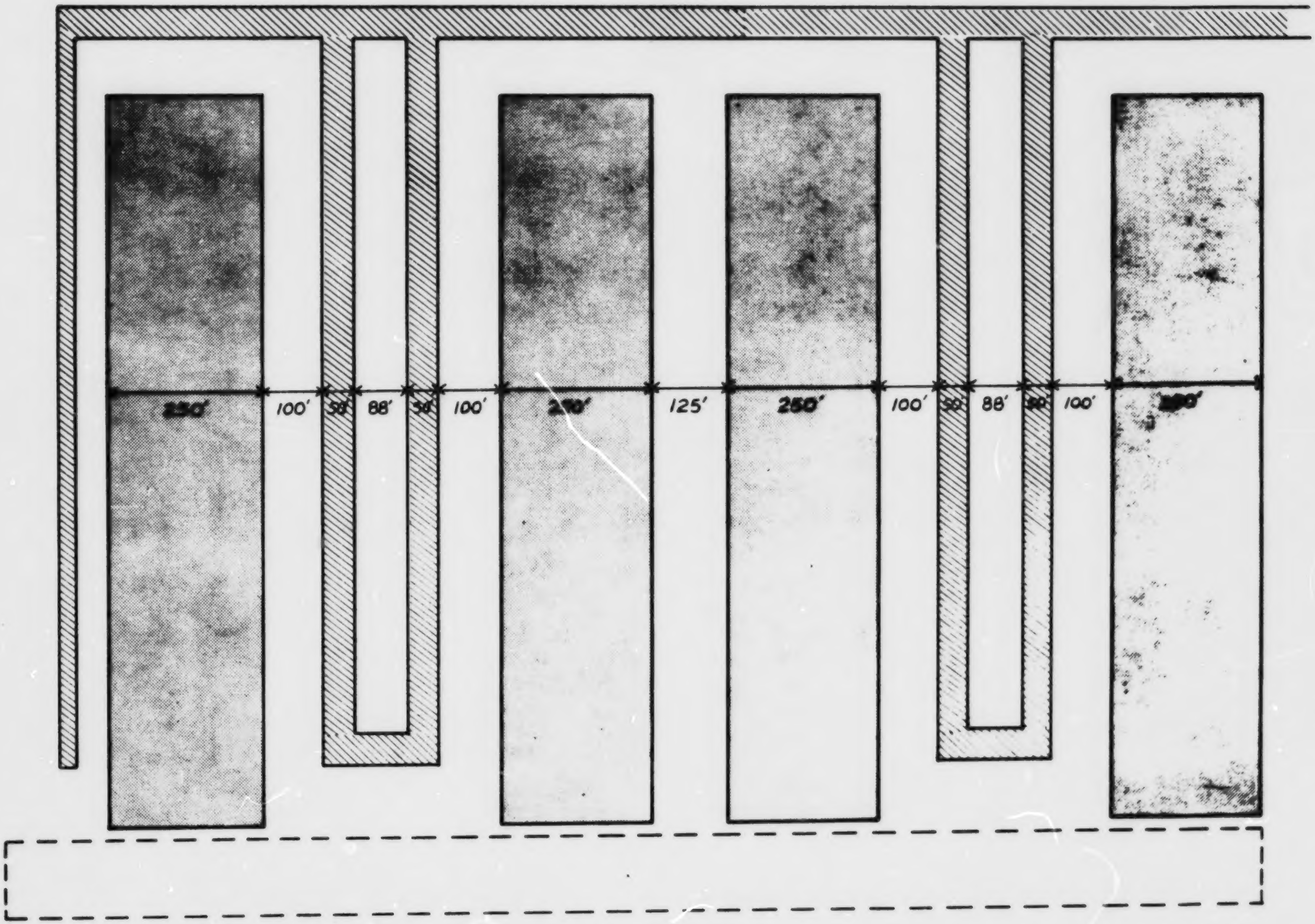
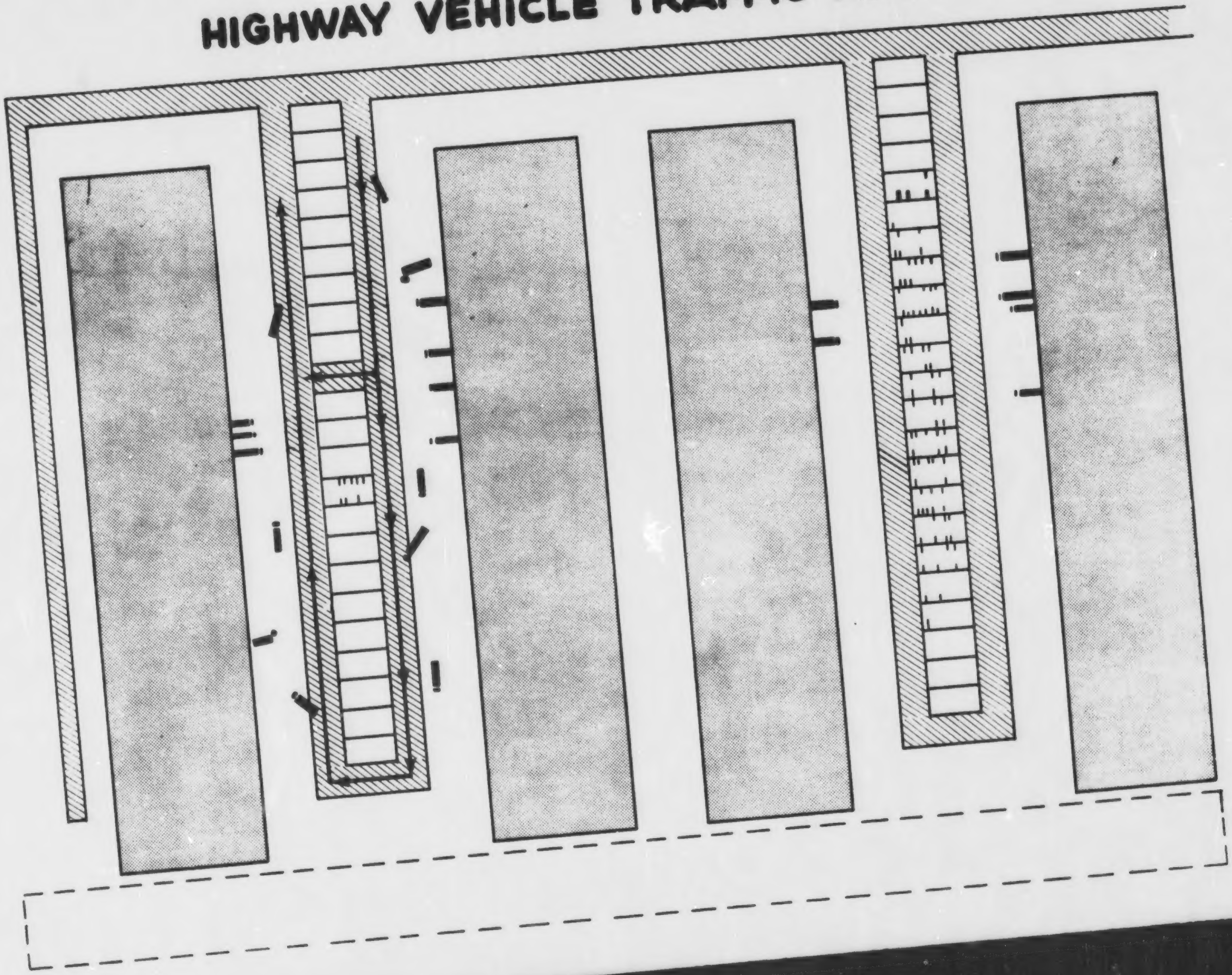


FIGURE-12

HIGHWAY VEHICLE TRAFFIC FLOW



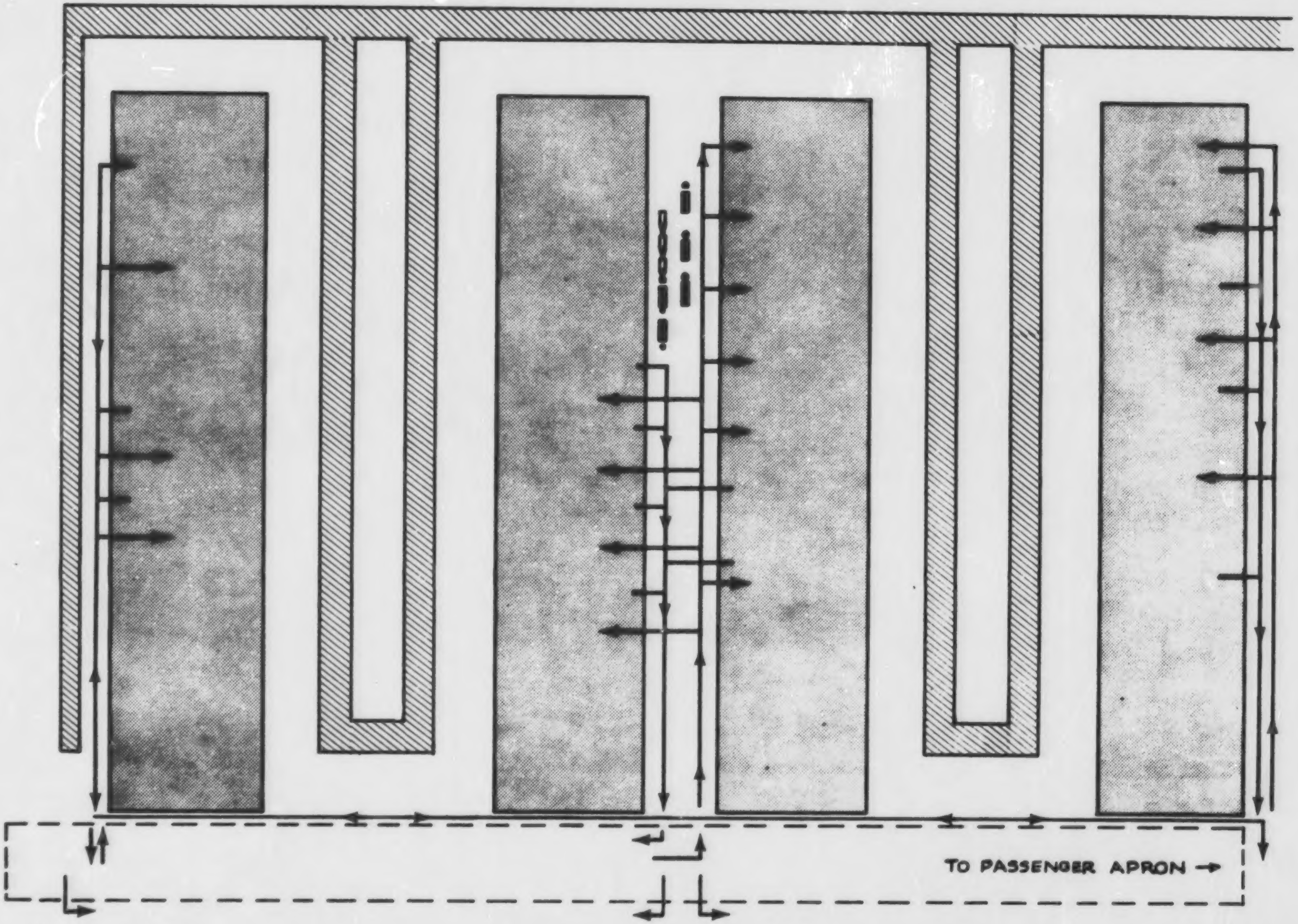
Automobile and bus traffic would run in lanes parallel to the truck traffic but would turn off the access road to the right into parking areas or into bus stops. In leaving the area they would reenter the access road and continue around the right-hand side of the access road until they reach the spine road.

We recommend a 50-foot-wide access road because the amount of traffic, the amount of entering and leaving of the access road by trucks and by cars, and the need to separate the two flows of traffic make it necessary to have more than a 30-foot road. A 50-foot road would provide four 12-foot lanes of traffic.

All cargo to or from the airport on motor vehicles would arrive and depart from the access road. All apron vehicle traffic would move between the cargo buildings and the common loading facilities and the passenger terminal apron on separated roadways as shown in Figure 13. These would include vehicles carrying passenger belly containers or vehicles containing loose cargo pieces for end-stowing in passenger bellies, container or pallet transporters and safety, supervisory, and security vehicles. These different vehicles would be mixing in the same traffic pattern between the common-user loading dock and the cargo terminal buildings. As they are of widely varying sizes and travel speeds, it would be safer to provide the wide access area as shown in the drawing. The traffic pattern provides for travel between the cargo area and the passenger area on roadways separate from the cargo aircraft apron.

FIGURE - 13

APRON VEHICLE TRAFFIC FLOW



A pallet bypass system would fit in the area between the two cargo buildings or at the apron end of the cargo building. This location would help maintain the separation of road vehicles from apron vehicles. It would add a facility for the operator of the common loading facility outside the original projected boundaries. Equipment for this area is discussed in a later section.

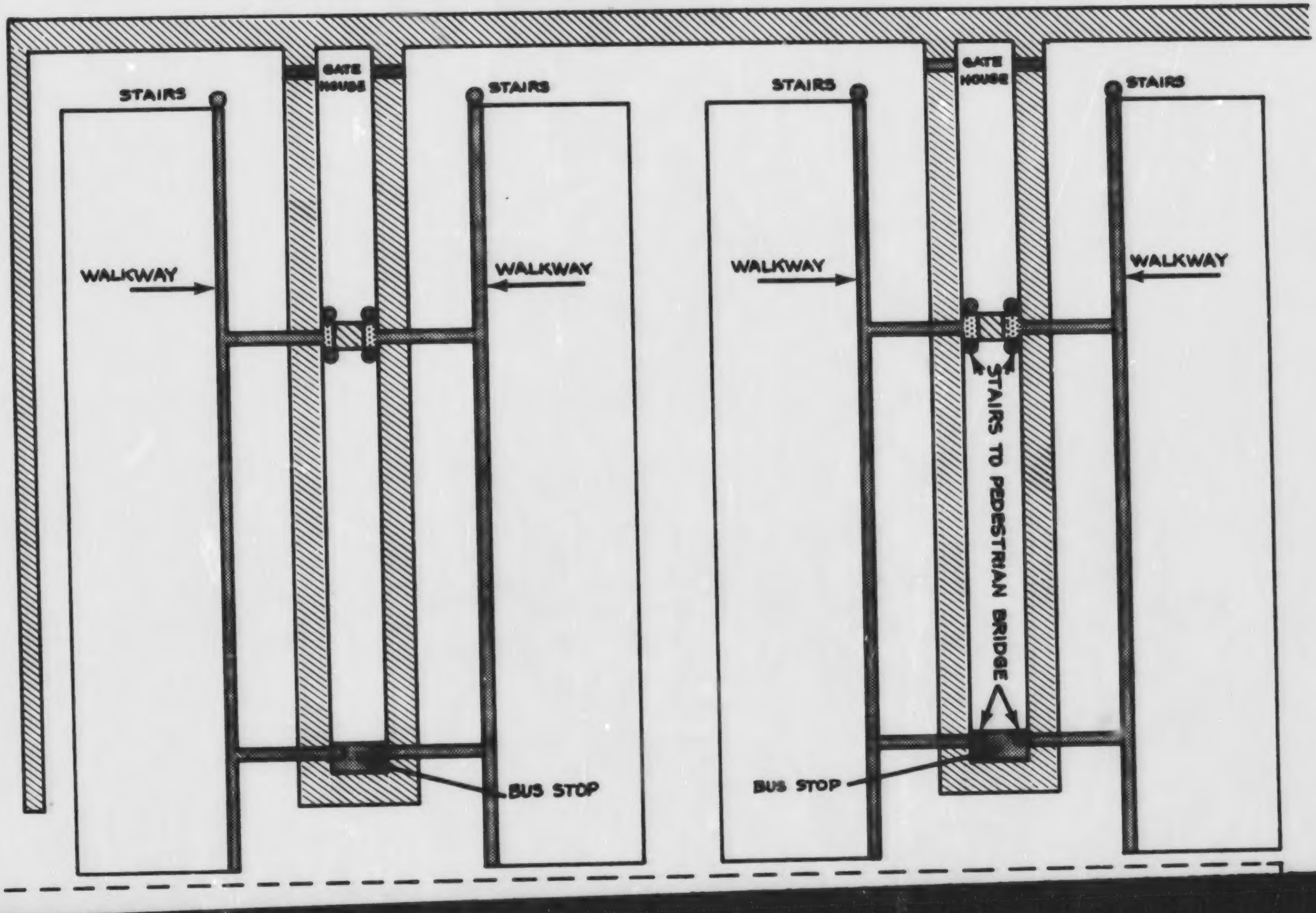
It would be especially desirable to separate the pedestrian traffic from the truck traffic to and from the terminal buildings for reasons of safety and security. In Figure 14, we have shown a suggested layout of pedestrian bridges from the automobile parking areas to the cargo buildings at an upper level. The bus stops would be in the auto parking area and the bus passengers would use the same bridges. The controlled access of pedestrians to the cargo buildings can provide cargo security as well as personnel safety if all employees or visitors are passed through guard points on the access bridges.

If this security approach is taken, a chain link fence down the center of the loop road would control the access to the terminal buildings at ground level and still provide two lanes of traffic for vehicles entering or leaving the terminal area and two lanes of traffic for access to the employee's parking area.

Within the parking area, there could also be an employee service facility which would include the bus waiting room, meal facilities,

FIGURE - 14

PEDESTRIAN BRIDGE LOCATIONS



safety and first aid facilities, and perhaps employment offices or other central service functions. These facilities would be duplicated in each access road loop as the terminal expands.

Gate house

Entrance into and exit from the access loop should be controlled at a gate house at the intersection of the access loop and the spine road. This intersection is also the point at which traffic into the access loop crosses traffic exiting from the access loop. This intersection is created by the procedure using a clockwise traffic pattern on the access loop and a right-hand drive traffic pattern on the spine road. If the spine road could be operated with left-hand drive there would be no intersecting traffic at this point. The vehicles would enter from the left-hand into the access loop and leaving the access loop would turn left onto the spine road.

Crossover road

If the suggestion for a centerline fence on the access loop is not adopted, the access loop should have a crossover road about halfway down the loop to allow trucks delivering or picking up from the building section farthest away from the apron to short-circuit that part of the loop near the apron, saving time for the truckmen and saving congestion on the far end of the loop. Although this short-circuit would eliminate part of the auto parking space in the access loop, total parking space still appears to be adequate.

Truck loading/unloading docks

The general plan as proposed by BANAIM calls for cargo buildings that are 250 feet wide. The typical cargo terminal is considerably narrower, on the order of 100 feet. The wider building is cheaper to build (per unit of area) and is more adaptable to mechanization or automation than narrower buildings. However, the wider building has fewer truck docks (positions) than a narrow building of the same area.

We estimate that the maximum throughput (tons handled on or off aircraft) of a 1,200 x 250-foot building and a 500 x 130-foot freighter dock will be about 480,000 short tons per year assuming that the building is a common-user terminal. Assuming that 40 per cent of the cargo is inbound, 20 per cent of the inbound cargo is air-to-air, and 260 operating days per year (5-day week), an average of 1,500 tons per day will pass across the truck dock. Assuming, further, that 25 per cent of the tonnage arrives or leaves on pallets, palletized cargo can be handled at 20 tons per hour per position (door), loose cargo can be handled at 3 tons per hour per position and that each position works 8 hours per day, then 50 positions will be required. The 1,200-foot building could accommodate 50 positions if 24 feet were allowed for each position. While our assumptions of 260 days per year, 8 hours per day and the productivity of 20 and 3 tons per hour are conservative, thereby allowing for some "peaking" in cargo movements, we feel that 50 loading and unloading positions with 20-foot spacing is marginally acceptable in the sense that truck queues of considerable length may form because of congestion caused by minimum storage space by each position (just inside the building).

If the cargo building is not a common-user facility and the building is partitioned off for several airlines, the average throughput of the building will be reduced but the "peaks" in cargo movements will be more severe. Therefore, 50 positions is marginally acceptable under these conditions as well.

Further investigation of customer practices will be required before it can be determined if 50 positions will be adequate. (Note: current practices are probably not accurate since we are projecting between a two and threefold increase in tonnage moved through Montreal). If, for example, the air-to-air ratio, or the palletization ratio, is higher than we assumed or if the average load per truck increases (thereby increasing position productivity), 50 positions may be adequate. A common-use facility would be more likely to find 50 positions adequate than a facility operated by many airlines.

Parking

We can roughly estimate the employee parking requirements for the parking area between two cargo buildings by estimating throughput of the cargo buildings and manpower associated with that throughput. The total building area in the cargo-handling buildings and the freighter dock amounts to 730,000 square feet. This includes 300,000 square feet in each of two cargo buildings and 130,000 square feet in a common-user dock of 130 feet by 1,000 feet (half of the freighter dock length).

Using techniques described later in this chapter we estimated that the daily employment in the two buildings will be between 600 and 1,000 men depending on the degree of mechnanization and the amount of cargo moving via a pallet bypass system. These employees when divided into three shifts would probably include 50 per cent of the employees on one shift and 25 per cent each on the other 2 shifts. Therefore, at most, and including overlap, 75 per cent of the employees would be on the premises at the shift break.

We estimate car parking capacity on the basis of a 60-foot module and a distance between the legs of the access road loop of 88.5 feet. This distance allows 10 cars parked at right angles to an aisle. Two rows of cars and the aisle can fit in a module of 60 feet with approximately 18 feet for each car on each side of the aisle and 24 feet for the aisle. These are very liberal car parking area allowances and more cars can be accommodated in a tighter pattern.

The parking capacity between two cargo buildings is approximately 400 cars inside the access loop (before adjustments) and 100 cars in the area between the cargo buildings and spine road for a total of 500 spaces. If we eliminate about 60 auto parking spaces from inside the access road loop to allow for a short-circuit road and to allow for the service building including bus stops, there will still be over 400 parking places. Since some of the employees will be traveling in car pools and some will be arriving by public transportation, 400 spaces should be adequate.

As we stated above, typical cargo terminals are on the order of 100 feet wide. The truck parking areas at these terminals are typically 150 feet wide, allowing 100 feet for vehicles to maneuver in and out of the truck docks and 50 feet (on the other side of the road) for truck parking. Many of the airlines or terminals operate their own pickup and delivery trucks and trucks are parked on the terminal premises when not in use. Thus, typical terminals have a parking area that is one and one-half times the building area.

The general terminal plan proposed by BANAIM, Figure 11, allows for 100 feet of truck parking, or 40 per cent of building space. The 100-foot width will not allow for parking idle pickup and delivery vehicles. Therefore, adequate truck parking will have to be provided if the terminal operator supplies pickup and delivery services. Assuming a single truck can pick up or deliver a total of 8 tons per day and using the assumptions described in the discussion on truck loading/unloading docks (above), 190 pickup and delivery trucks will be required for each cargo building. If these trucks are to be parked at the terminal, between 48,000 and 80,000 square feet of parking space will be required for each cargo building depending on whether the trucks are mass parked or parked for random access. The parking area between the buildings does not have sufficient space for the two buildings it must serve. Therefore, the area between the spine roads must be developed as parking.

Freighter dock

Later in the chapter we show that the general layout of the common-user freighter (all-cargo aircraft) dock should provide for four aircraft parking spaces in the intial development. These are shown in Figures 15 and 16 in two alternative layouts. The first layout (Figure 15) shows four aircraft which can taxi in and taxi out under their own power regardless of whether all the spaces are occupied at the time. The second configuration in Figure 16 shows four aircraft in taxi-in/tow-out position.

In the first configuration, all aircraft are served by a mobile elevator driven to the aircraft door after the aircraft is parked. Pallets are brought to and from the mobile elevator by transporters. In the second configuration, the aircraft taxi to a fixed loading bridge and pallets are brought to and from the aircraft by a conveyor system which is described more fully below.

The spacing of aircraft parking is based on DC-8 type aircraft. In a time horizon beyond the initial construction phase, wide-body, all-cargo aircraft will probably be introduced. The second-phase construction program can provide for handling cargo to and from wide-body aircraft in special upper- and lower-deck containers. These containers would require different equipment than the present pallets do, but the equipment at that time can be made compatible for wide-body containers and for pallets.

The design and spacing of aircraft loading fingers in the second phase can also be compatible for both sizes of aircraft, allowing both nose loading and side-door loading. There will be adequate room for

FIGURE-15

AIRCRAFT PARKING : TAXI IN/ TAXI OUT

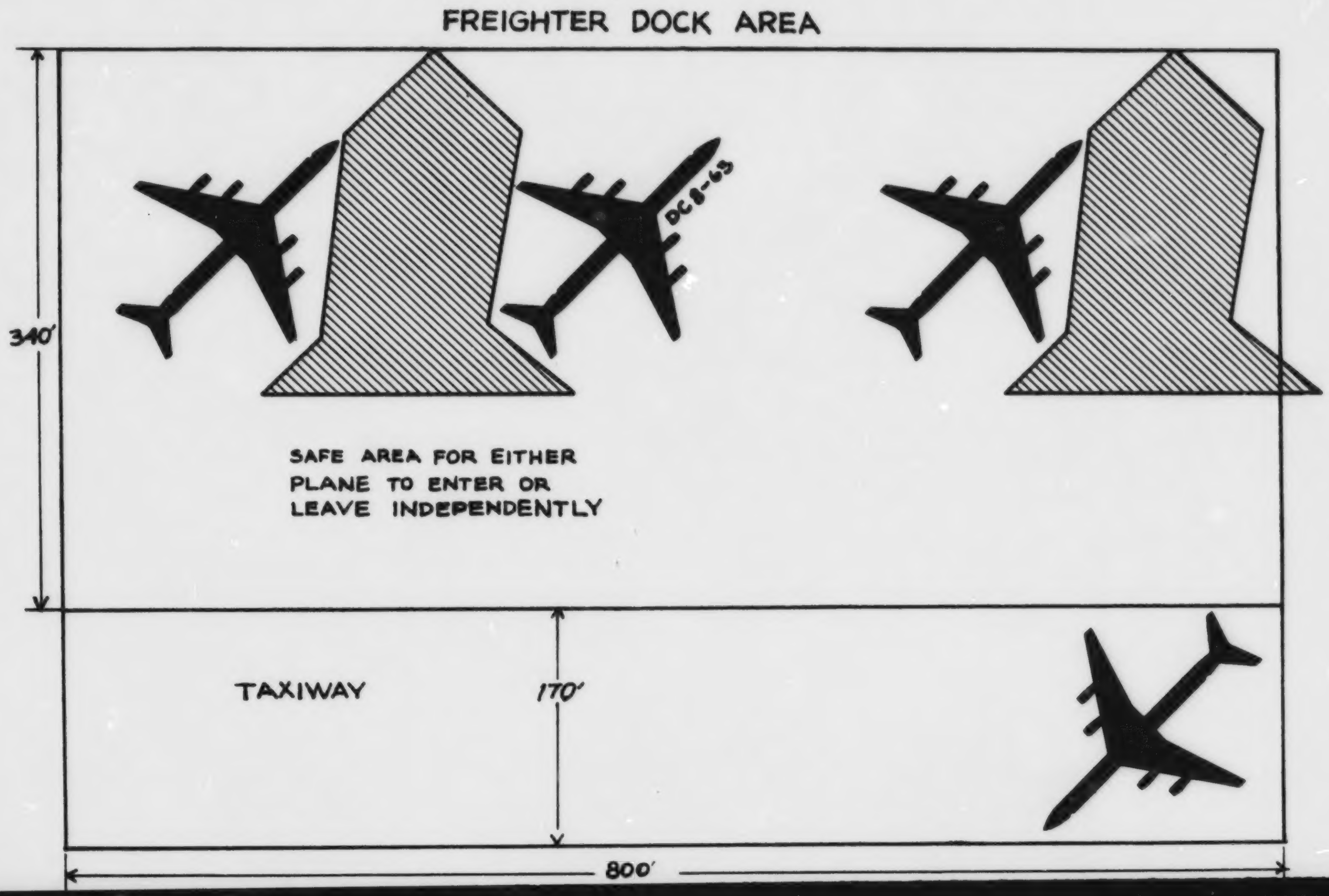
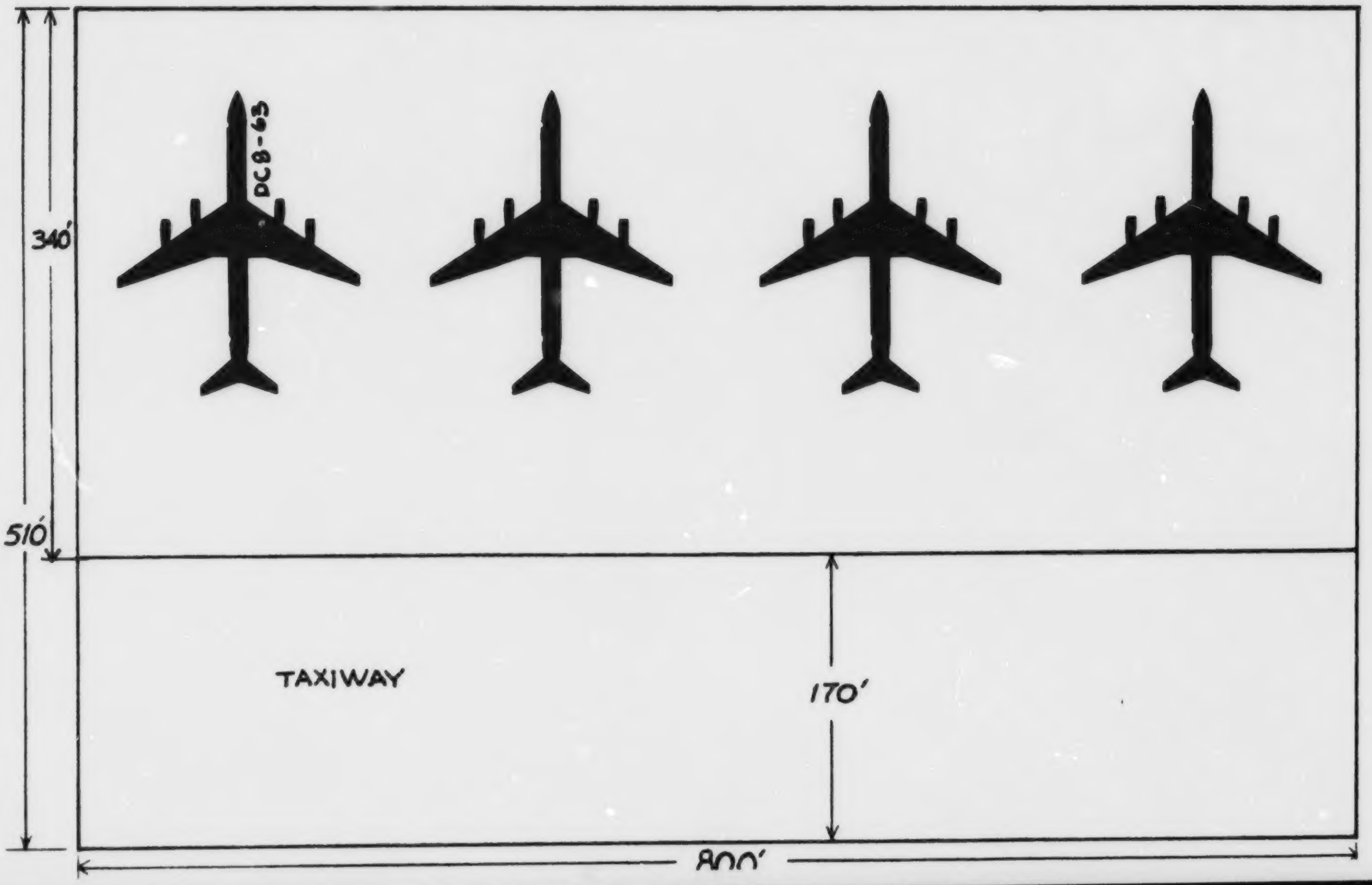


FIGURE -16

AIRCRAFT PARKING : TAXI IN/TOW OUT

FREIGHTER DOCK AREA



parking the longer aircraft in the apron and still leave clearance for taxiing aircraft.

By using finger piers, the aircraft turnaround time at the apron position is minimized. The critical time measure for aircraft loading and unloading is the time to move a pallet inside the aircraft rather than the time to move it between the aircraft and the building. Because developments of cargo-handling gear for operation inside aircraft are likely to be in operation within a reasonable time horizon, we recommend that the Montreal air cargo center employ equipment compatible with the high-speed discharging and loading of pallets on aircraft.

We show the general layout of the initial freighter dock for four airplane positions in Figure 17. A more detailed drawing of a single module is shown in Figure 18.

The equipment will have the highest productivity if the pallets are conveyed to the aircraft at the height of the aircraft door, eliminating elevating and lowering time. The recommended layout provides for complete storage of all the pallets that can be carried in a stretched DC-8 on conveyors from the aircraft door to the freighter dock building and inside the freighter dock building. A separate line of conveyors in the freighter dock building and to the aircraft door provides room for the outbound pallets to be set up in advance and to be ready for immediate loading when the last inbound pallet is removed from the plane. These conveyors are at door height. When transit cargo is handled it will be

FIGURE -17

FREIGHTER DOCK

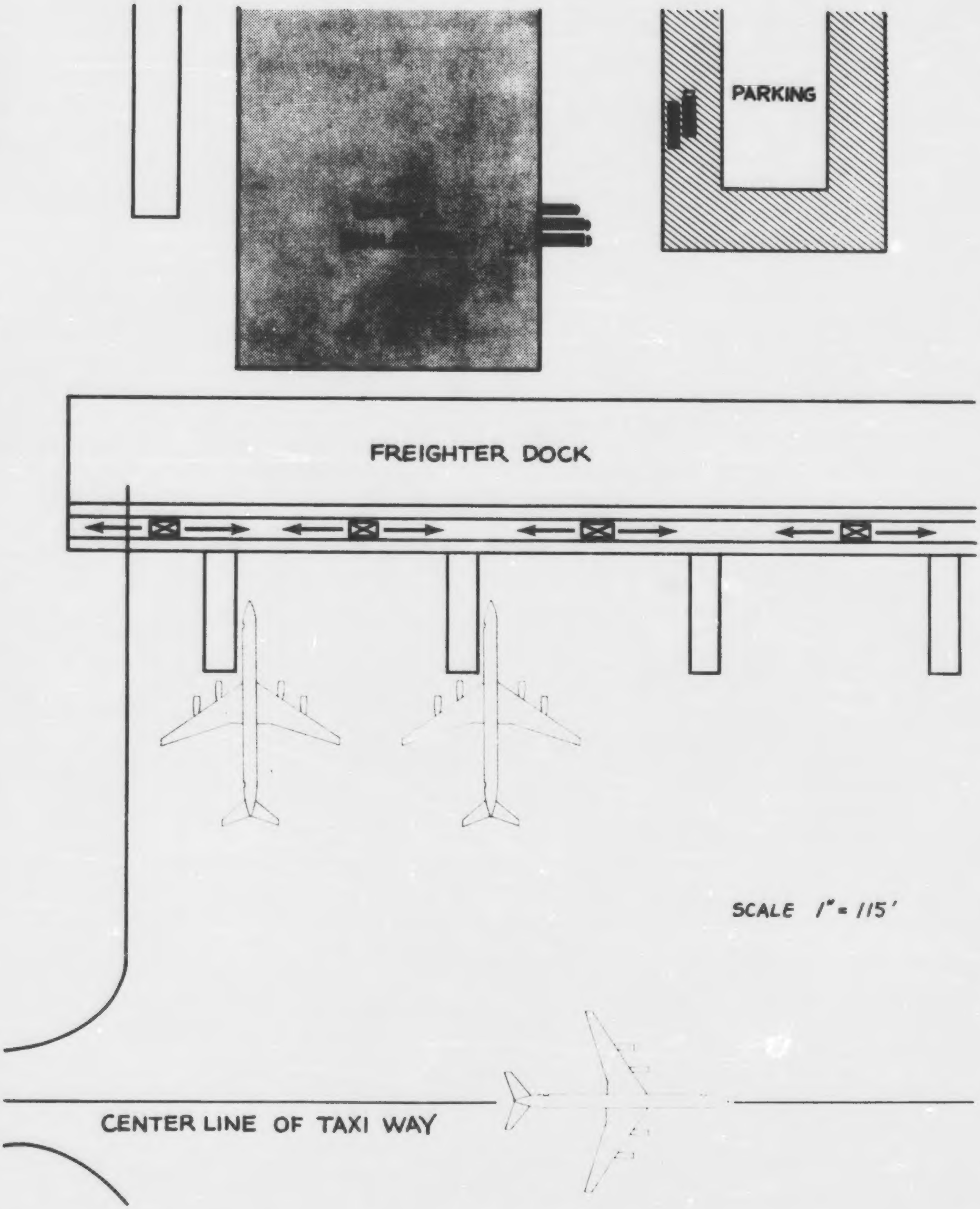
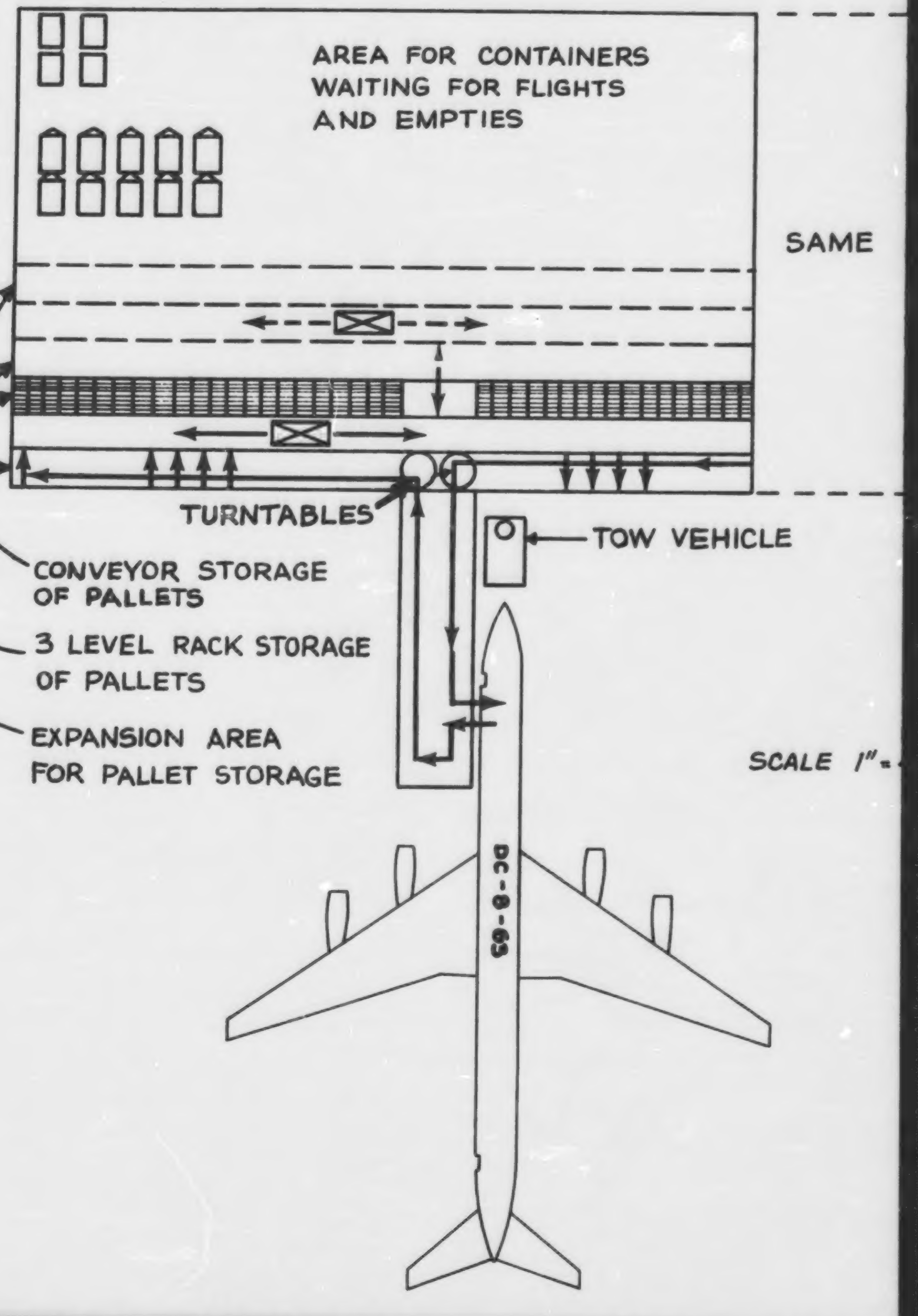


FIGURE - 18

FREIGHTER DOCK MODULE



necessary to set up only part of the outbound load and to save room on the conveyor inside the freighter dock to intermesh the received transfer pallets with the outbound pallets.

The equipment in a freighter dock module includes: pallet storage racks three levels high, an elevator transporter to service the three levels, conveyors for holding inbound pallets and prepositioning outbound pallets in load order, turntables for turning pallets between the storage conveyors and the conveyors on the finger piers -- one each for inbound and outbound -- and conveyors on the finger pier from the turntable to the aircraft door. At the aircraft door a specialized unit for matching the height of the door, which may vary with load, is also required.

In the following table we have shown the number and cost of each of these system components in the aircraft module:

	Number Per Module	Unit Cost	Total Cost
Elevator-transporter	1	$120,000	$120,000
Storage positions:			
Friction drive	120	1,750	210,000
2-way conveyor	18	10,000	180,000
Loading finger	16	4,000	64,000
Turntables	2	15,000	30,000
Aircraft door transfer unit	1	10,000	10,000
			$614,000*
Building			
Freighter dock 130' x 200'	@ $30/sq ft	$780,000	
Loading finger 25' x 60'	@ $30/sq ft	45,000	825,000
			$1,439,000

Annual cost of the equipment and of the freighter dock building and pier building, using the cost method described later in this chapter, is $550,000. At a throughput of four aircraft per day, this cost amounts to $380 per aircraft. However, the high-speed capability of the mechanized system would permit aircraft turnaround in less than one hour and the system could easily handle eight to ten aircraft per day, even though there is bunching at certain peak hours. Expansion of the storage capacity of the system would be necessary if eight aircraft were loaded and unloaded at the finger pier. The expansion can be aligned parallel to the initial conveyor lineup and pallets passed through from one line to the other as illustrated in Figure 19. The expansion would require an additional elevator-transporter, 144 additional function drive storage positions and a pallet transfer device (cost $10,000). The annual cost of the expanded freighter module would be $720,000. This cost would be $250 per aircraft. If each aircraft exchanged 36 pallets, the cost would be $7 per pallet.

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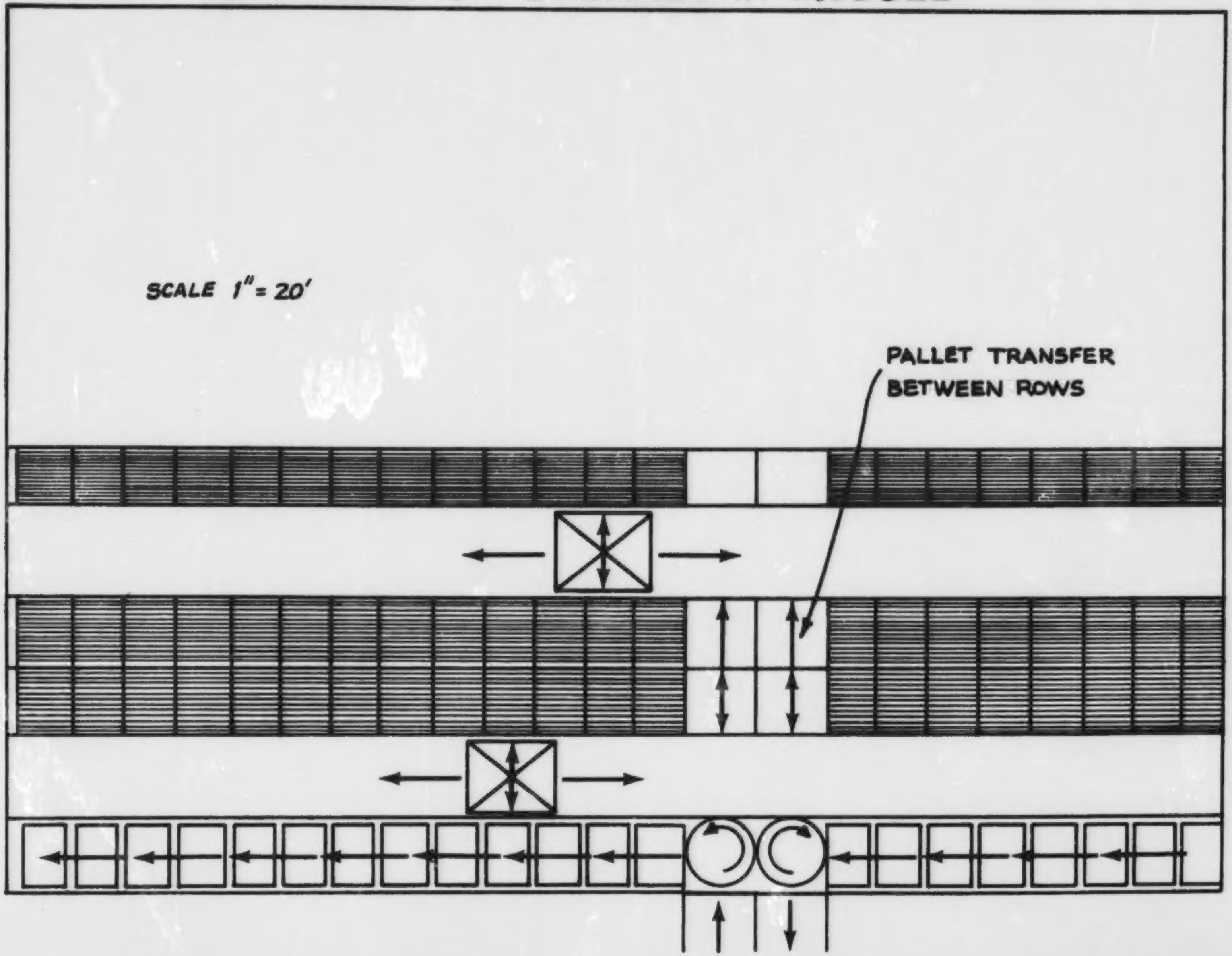
* U.S. prices; Canadian prices inflated 6 per cent.

The alternative method of handling pallets on and off aircraft using mobile loaders (taxi-in/taxi-out aircraft parking) and using two transporters between the mobile loaders and the storage unit would cost $91,000 per loading unit. This $91,000 would replace the $149,000 for the loading finger pier building, the loading finger conveyors, two turntables and the aircraft door transfer unit. However, this alternative system is likely to be slower and certainly more exposed to weather elements. The two-way conveyor which is essential to prepositioning outbound pallets while receiving inbound pallets could be used with the mobile transporters as well as with the loading finger. Some compromise in the cost of a two-way conveyor can be made by reducing the number of pallet positions which are accessible to the elevator transporter in the storage building. Each position, with an indexing conveyor rather than a two-way conveyor, saves $6,000 on equipment costs. Some flexibility is lost as pallets would have to be in the two-way conveyor position before they would be available to the elevator transporter. If only one position was available at the end of the

FIGURE-19

EXPANSION OF STORAGE IN MODULE



conveyor line, then all pallets would have to be picked up in order of discharge from the aircraft. This would not be as satisfactory for delivering bypass pallets to waiting trucks.

There is a finger-pier system, similar in concept to this recommended system, in use at the Flying Tiger terminal in Newark. However, instead of a turntable and a two-way conveyor line for storing units coming off the conveyor from the airplane door, the elevator transporter takes the units as they arrive at the building end of the finger pier and stores them in other positions. Furthermore, there is a single conveyor line from the storage building to the aircraft door, and all inbound containers have to be cleared before outbound containers can be conveyed to the aircraft door.

Containers and bulk belly cargoes

A section of the common freighter dock would be devoted to storage and assembly of containers and transporters for belly cargo. Empty containers and carts would be stored in this area for the airlines and transported to the cargo-handling buildings, and assembled at the freighter dock into trains for transport to the passenger terminal. These transport trains could serve one or more airlines in each train to improve the efficiency of transport over the long distance to the passenger terminal. Schedule requirements would have to be met regardless of the number of containers to be transported on any trip.

These trips would not go on the cargo apron to the passenger terminal. They would travel through the freighter dock to the end of the cargo apron, and from there to the service road into the passenger terminal. The exceptions that would go on the cargo apron are the containers or carts for belly loading of freighter aircraft.

The large floor area available in the freighter dock would be sufficient for storing of containers and carts and assembling of transport trains. For future expansion, these loads could be stored in multi-level racks like the pallets.

The common-user terminal operator would provide the towing vehicle and carts for bulk freight. The special containers and their specialized dollies would belong to the airlines, either directly or via a leasing arrangement. In principle, the common-user dock operator would not own any equipment that left the airport or any necessary equipment unique to a single airline. The amount of this equipment that will be owned by the terminal will therefore depend on airline handling method and is not considered here.

Pallet bypass

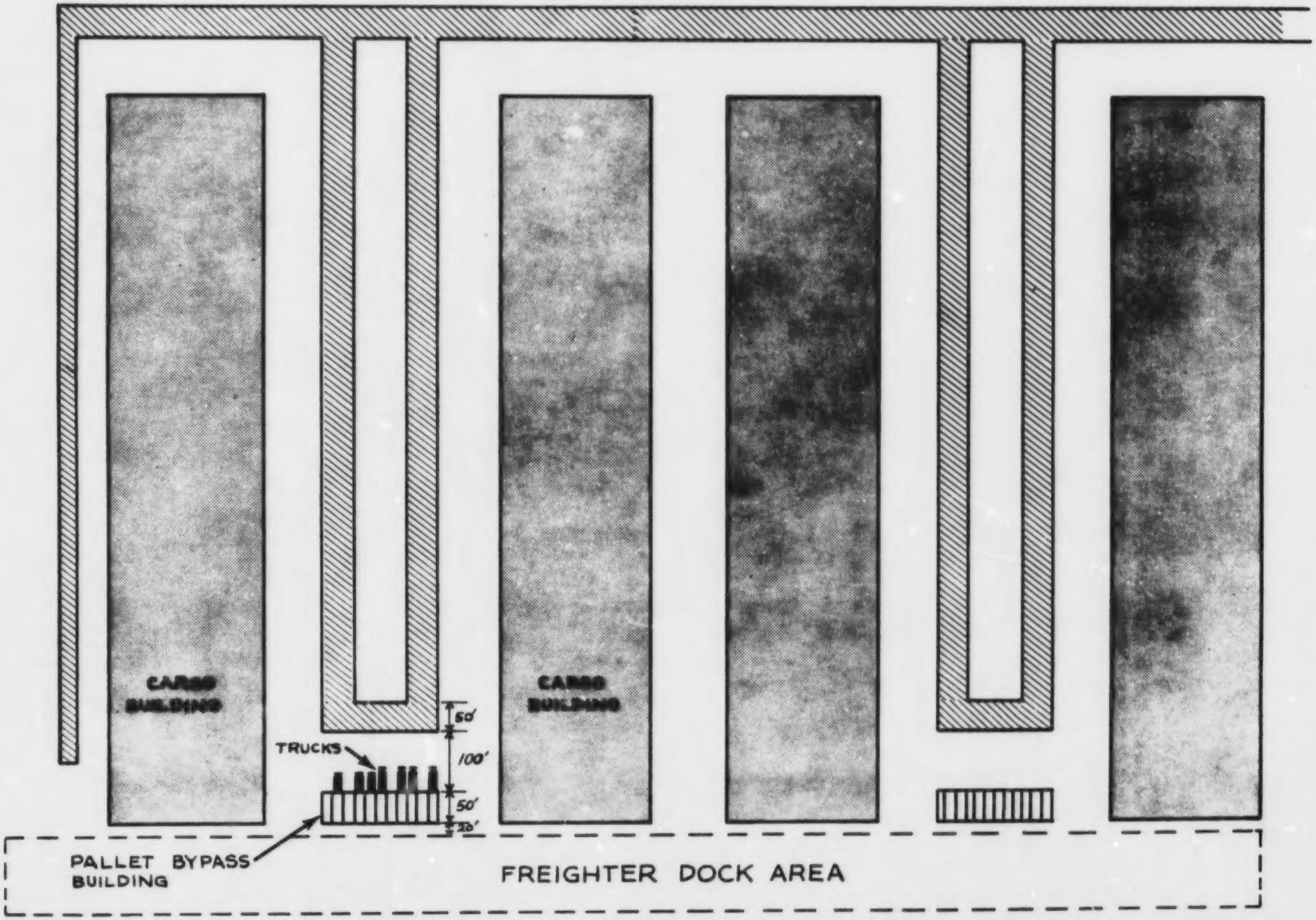
We estimate that 25 per cent of the local traffic will be transferred in full pallets. A system is required to bypass the cargo buildings with this cargo to save time, handling cost, and additional equipment at each cargo section. The bypass system should be off the apron to maintain separation of vehicle traffic. We recommend placing it at the end of the access loop or at the apron end of the cargo building.

The access road loop would be shortened by 50 feet to allow the placement of the bypass system conveyors at the end of the loop as shown in Figure 20. The 50-foot building will easily allow for receiving or dispatching a set of four containers on a single trailer by lining up the containers on the bypass system for immediate pickup by the truck. If a truck is to deliver containers and receive containers, there will either be a delay while the containers are delivered or removed from the bypass system and put into storage, and the outbound containers are removed from storage and put on the bypass system; or, the truck will deliver containers on one line of the bypass system, and then repark at another line, which has been previously loaded with outbound containers for that truck.

As an alternative to a separate pallet bypass system at the end of the access road loop, the pallet bypass system can be installed at the apron end of one of the cargo buildings. Part of the building space -- about 48 feet -- can be set up with four conveyors for handling pallet-carrying trucks and trailers. These doors would be equipped for matching the height of truck beds. The variable height section could then match the height of conveyor storage inside the building.

FIGURE - 20

PALLET BYPASS BUILDING



Because the breadth of the building -- 250 feet -- is far in excess of the requirements for the terminal bypass arrangement, the remainder of the building section can be devoted to other functions of the common-user terminal operator. Although this arrangement uses part of the cargo terminal building, it does keep the pattern of access to the buildings at the apron end more open and allows trucks to be used at every door along the cargo building. A separate terminal bypass building would partially block access in that area to the cargo building.

Cargo buildings

An alternative to common-user cargo buildings is to have each airline, forwarder, broker, or other participant in air traffic able to rent the amount of space he requires. A cargo terminal operator who contracted with one or more participating airlines to handle their freight would rent space in the building just as any airline would. The notion that a common-user operator would serve all airlines on a compulsory basis does not have a great deal of acceptance with airlines. The compulsory use of the common freighter dock achieves most, but not all, of the savings available from joint operations. Additional savings that might be achieved by more efficient throughput in the cargo building are not as critical because they do not have any implications for additional apron space and taxiways, as fully independent terminals would have. Cargo flow would be from the truck area, through the cargo building, to the apron vehicle area behind each cargo building, and hence to the common freighter dock or to the passenger terminal. Exceptions would be the bypass pallets which move through the bypass system and not through a cargo-handling operation.

Office space for the cargo department would be located on the cargo level; office space for all other functions would be on the upper level, and would be accessed from outside via walkways connected to the pedestrian overpasses. This pattern separates people movements and vehicle movements for safety and security, and so permits close contact between the paperwork functional areas and a cargo-handling functional area for each operator. There would be inside stairways between the cargo-handling level and the office level.

Cargo-handling equipment in the cargo buildings would be the choice of the operator. While there are many concepts we could recommend in this report, they would all be contingent upon each particular operator's throughput and pattern and would not be of particular interest to the Montreal Airport planning staff.

Terminal Procedures

Terminal procedures and information flow go hand in hand because of the necessity to maintain positive control of the cargo. The basic procedures and information flow discussed below will generally apply to common-user terminals, proprietary terminals or a combination of the two such as proprietary cargo buildings and a common-user freighter dock -- only the magnitude varies. In the following discussion we will refer to the cargo building operator and the freighter dock operator as if they were independent, realizing that they could actually be one in the same.

The key to a successful air cargo terminal is proper control of the cargo. Air shipments are generally small, less than 500 pounds, and may consist of many small packages. Each package must be properly marked. The terminal must define procedures to "track" the cargo, either inbound or outbound, through the terminal and keep records on the physical location within the terminal and the status of the shipment. This will require that each physical handling is checked to ensure that cargo is not "lost". The terminal's data bank must be in a form that the status information may be retrieved in amatter of seconds. The actual amount of data that is stored at any given time is large, especially for a common-user terminal. We indicated in the discussion above on truck loading/unloading docks that the throughput of a single cargo building and a quarter of the freighter dock will be about 480,000 tons annually. Assuming an average of 500 pounds per shipment, there will be over 5,000 shipments moving through the terminal on an average day. Information flow of this magnitude requires a computer to provide proper access to the information.

Procedures and information flow will be required for other purposes besides controlling the cargo. Unitizing, sorting and storage positions must be assigned. The operation of the freighter dock must be carefully preplanned in order to expedite aircraft turnaround. Empty pallets must be controlled to ensure that air carriers receive their own equipment or that interchanges are acceptable to both the owner and user. Additionally, a warning procedure must be developed to protect against cargo remaining in the terminal for an inordinate length of time. Surprisingly, a new terminal on the east coast of the United States overlooked this aspect of cargo control and much to its embarrassment discovered that many inbound shipments were not being picked up by the consignees in a timely manner. A few consignees were using the terminal as a no-cost warehouse for several weeks at a time.

The cargo building operator must receive a request for air transport from the shippers and create the necessary documentation. He must also arrange the schedule for transfers of cargo between the cargo building and the freighter dock. When the cargo arrives at the cargo building, it must be checked against the waybill and taken to the proper location within the cargo building for unitization. The cargo is loaded onto a pallet (or bulk cart), checked and the proper records updated. Instructions for the freighter dock operator concerning the pallet are created at this time. Their instructions state flight number, loading sequence number, etc. When pallets are transferred to the freighter dock operator they are again checked to ensure that the intended pallets are being transferred.

When the cargo building operator receives inbound cargo from the freighter dock operator, he must also receive instructions as to its disposition. The pallets are seperated into individual shipments, checked and stored to await arrival of the consignee or customs inspection. The storage location in the cargo building must be noted in the data bank. If the cargo is to be transshipped, it must be taken to the proper unitizing area.

The cargo building operator in effect reserves space at the freighter dock and at the pallet storage area for a specific time block. The cargo building operator must agree to make outbound pallets available at a stipulated interval prior to the arrival of the airplane. He must also accept the inbound pallets at an agreed time. The cargo building may arrange for longer-term storage in the freighter dock building, and the freighter dock operator will provide storage units accordingly. The freighter dock operator, in turn, must provide facilities to unload and reload an arriving airplane within a specified time. Some flexibility should be allowed because of the uncertain effects of fluctuations in arrival time, fluctuations in cargo-handling time, and an occasional equipment failure.

The freighter dock operator will provide the pallet transporter equipment for moving loaded and empty pallets between the cargo building and the freighter dock. The standard allowable delay time and penalty for service failures should be established in advance. Similarly, the freighter dock operator must deliver and receive belly containers and bulk carts. He will provide the equipment for moving these units between the cargo building and the freighter dock, and will also provide equipment for moving the units for passenger flights to the passenger apron on schedule.

The freighter dock operator will specifically not be responsible for customs supervision, because all cargo under his control will be delivered only to or at the instruction of the cargo building operator. The cargo building operator will perform the necessary pallet breakdown and sorting for sampling of cargo for delivery to customs.

The freighter dock operator will unload and hold all palletized cargo and will hold units of other cargo removed from freighter bellies or transported from the passenger apron. On the instruction of the cargo building operator, he will reload the transfer cargo, or will deliver bypass cargo to the customer, or will deliver pallets or other unit loads to the cargo building. On outbound cargo, he will receive pallets from the terminal bypass system or from the cargo building, and hold them in the freighter dock until loading.

The freighter handling procedure will follow a cycle of steps as follows: the freighter dock operator will receive a load plan from the cargo building operator. He will use the elevator transporter to load pallets on the outbound conveyor line to the loading finger in the correct loading sequence. This process can go on while the plane is at the loading finger and inbound pallets are being removed from the plane and stored on the inbound pallet conveyor line. As soon as the plane is clear of all pallets to be unloaded, the outbound pallet line is activated, and the pallets are positioned and locked in the cargo plane in the correct sequence.

Simultaneously, a preplanned load of belly cargo is positioned underneath the freighter and a crew then stacks the pieces in the belly compartment. Some freighters may use cargo containers in the belly section. In that case, a load plan for the belly section must also be provided by the cargo building operator, specifying the order of loading of containers. On completion of the loading, the freighter dock operator provides a manifest of cargo loaded to the cargo building operator. For deplaned cargo, he also provides a manifest checked against the cargo unloaded, and notifies the cargo building operator of any discrepancies.

Because the common-user freighter dock is servicing a number of airlines and a greater number of destination points, it is essential that foolproof procedures be devised to prevent misloading of containers or pallets. The load plan can be used as a check list at the aircraft door to be sure that the correctly identified pallet is loaded. The same manifest can be used for receipt. It is probable that the air carrier will provide a loading supervisor to assure that the correct pallets are loaded on the correct airplane in the correct sequence.

Air Cargo Terminal Costs

This section discusses the development of air cargo terminal costs. The costs developed below were used in the analysis of Montreal's share of the air cargo markets and hence the discussion is generalized. The specific cost analysis, which follows the same approach, appears later in this chapter.

We have assumed that New York would be Montreal's prime competitor and therefore we developed the costs of a hypothetical New York air cargo terminal for use in the market-share analysis. Because of the general nature of this portion of the cost analysis, we have assumed that both Montreal and New York have the more typical arrangement where the truck parking area is one and one-half times the building area.

The major factors responsible for a difference in cost between a New York air freight terminal and a Montreal air freight terminal are land rent, labor wage rates, construction costs, and equipment costs. The first three factors are lower in Montreal, the fourth is higher.

There are other possible differences which we have not quantified in this analysis. These include loss and loss-prevention costs, air and highway congestion, the effect of inflation on new investments (in Montreal) versus existing investments (in New York), the relative possibility and the impact of multiple-user terminals on cost, and the relative potential for mechanizing cargo terminals. These latter factors were not quantified because there is insufficient data support and because they are subject to radical change. New York's disadvantage in congestion and advantage in existing facilities may reverse when New York builds another facility at higher cost with less congestion.

Impact of differential factors

In order to assess the impact of the differential factors on relative cost per ton handled at New York and Montreal, we constructed several cases involving different assumptions as to the cargo throughput, inbound/outbound cargo balance, relative percentages of transfer cargo (plane-to-plane movements) and local cargo (truck-to-plane movements), relative percentages of containerized or palletized cargo, and level of cargo-handling mechanization. We developed a cost model* to generate costs per ton for each of the different cases. The following parameters define the cases considered for which we made cost estimates:

Annual throughput in tons (ST): 5,000; 25,000; 32,500; 50,000; 100,000
Per cent inbound: 52, 61
Per cent plane-to-plane transfer: 25, 50
Per cent palletized (inland side): 25, 50
Mechanization: low, high

The parameters of the above factors yield eighty distinct cases for each of two locations or a total of 160 cost estimates. The plane-to-plane ratio is applied against the inbound cargo.

Cost model

We developed our cost model using a number of separate sources for the data required. The costs covered in our model include: land rent and improvements, buildings, equipment, and labor as required to handle cargo planes, passenger plane cargo containers, truck receiving and dispatching, documentation, and security. For each of these cost areas, we estimated the separate requirements of land, labor, construction, and equipment corresponding to the specifications of the separate cases. For example, the case of the higher level of mechanization implies more equipment, less building area, less land area, and less labor per ton of throughput. Similarly, the higher level of palletized cargo implies less building area, less land area, and less labor. The higher level of plane-to-plane transfers implies more labor, equal building areas and equipment, and less truck area and land area. We estimate parameters for each of these relationships. Finally, inbound and outbound traffic generate different requirements for building space and for labor, and therefore the different inbound/outbound ratios result in different costs.

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* See Appendix F.

Our costs do not include truck operations, conveying cargo and handling cargo to and from passenger planes, administrative costs, and marketing costs, nor, of course, do they include flying costs. Our sources and methods for developing the operating and cost factors in our model are described below.

Impact of throughput

Annual throughput capacity affects the several cost areas but not all of them proportionally. As a result unit costs are a declining function of throughput. The building areas, apron positions, truck parking, and security guards increase less than proportionally to throughput. Cargo-handling equipment is proportional to peak-day capacity which in turn increases less than proportionally to throughput.

Labor is assumed to increase proportionally to throughput. We may hypothesize that labor staff is proportional to daily capacity (as equipment is) and therefore less than proportional to throughput, but we have not as yet found any evidence to support this supposition and we chose not to assume it.

Requirements for mechanization and palletization

We have defined an unmechanized terminal as a terminal where there is no mechanization other than a few forklifts for handling pallets to and from trucks. All cargo is sorted by hand and manually moved about the terminal on push carts. A mechanized terminal is a terminal which makes extensive use of mechanical equipment such as forklifts, conveyors (powered or gravity), and tractors. An automated terminal is a mechanized terminal that utilizes devices for making logical decisions with respect to the operation of mechanical equipment such as package-sorting devices and unit-load storage and retrieval systems which operate under push-button or computer control.

We have analyzed both unmechanized and mechanized terminals in this analysis. We have not analyzed automated terminals for two reasons. First, there is not a sufficient number of automated systems in operation from which we can make generalized conclusions pertaining to their cost and performance characteristics. Secondly, there are indications that the automated terminals in operation are more costly than mechanized terminals of the same throughput.

The base space requirements for the terminal assume that cargo handling is relatively unmechanized and that about 25 per cent of the throughput is received from trucks or delivered to trucks on intermodal pallets or containers. The cargo handling-space is about three-fourths of the total space; the other fourth is for handling of pallets, storing of cargo, and other miscellaneous functions. We reduce our estimates of the cargo-handling space within the terminal if 50 per cent rather than 75 per cent of the throughput is not palletized (on the truck side). That is, the unpalletized throughput is one-third less and proportionally the space is one-third less. We estimated that more intensive mechanization would reduce the cargo-handling area by 50 per cent.

To summarize these impacts, the relative space required for cargo handling is as follows:

	Unmechanized	Mechanized
25 per cent palletized	1.000	0.625
50 per cent palletized	0.750	0.500

Cargo plane positions

We estimated the number of cargo plane positions required to serve the various levels of throughput. We assumed that half of the throughput moves by passenger plane and half by cargo plane. The capacity of each loading position is four aircraft turns per day, 50 tons transferred per turn, or 200 tons' capacity per position. The number of positions required is the daily peak tonnage, diminished by half to exclude passenger plane cargo, and divided by 200 to obtain required positions.

Loading position costs

Since this cost analysis is general, we analyzed the more typical arrangements of loading cargo aircraft using container lifts and transporters. The investment required for each loading position is the cost estimated for 1974 of one container lift and two container transporters. Total investment per position is $91,000 based on manufacturer's (Cochran-Western, Salinas, California) current 1972 budget estimates for this equipment (including transportation costs), inflated by 4.3 per cent per year. No installation cost is required for this kind of equipment. We assumed that the equipment would cost an additional 12 per cent in Montreal because of customs charges. This is an automotive-type of equipment, written off over a six-year life, and required maintenance is estimated at 20 per cent of original cost per year.

Truck parking

Space for truck parking is estimated to be 1.5 times the cargo area of an unmechanized terminal for the case of 25 per cent of plane-to-plane transfer. For the case involving a greater percentage (50 per cent) of cargo transferred between planes, the truck parking area is reduced to 1.25 times the cargo area.

Cargo-handling equipment

Cargo-handling equipment for a terminal that is relatively unmechanized requires an investment of $1,625 per ton of peak daily throughput at 1974 U.S. prices, including installation. The Canadian cost, allowing for 12 per cent duty and a lower installation cost, is about $1,725 per ton. The equipment cost in a mechanized terminal would be twice these costs. We have used a ten-year write-off on this equipment. The ten-year write-off requires a capital recovery factor of 32 per cent to obtain 15 per cent return on investment after taxes of 55 per cent, an average maintenance and repair cost of 10 per cent of original installed cost, and an insurance and tax cost of 2.5 per cent of installed cost.

The investment amount would be the same though the selection of equipment would change for different levels of palletization. For highly mechanized terminals, we estimate that the investment in handling equipment would double.

Total terminal costs

Table 29 presents the total cargo-handling costs at New York and Montreal for the various cases analyzed as well as the difference (Δ) in costs at the two airports. The unit costs decline smoothly as terminal throughput increases. The ratio of inbound to outbound cargo has a small impact on terminal costs, affecting the cost about two per cent or less.

The palletization ratio, the per cent of cargo that moves through the terminal without being depalletized and repalletized, has a significant impact on cost. An increase from 25 to 50 per cent will lower unit costs approximately 20 per cent. The impact of the plane-to-plane ratio is less than 6 per cent.

Table 29

TOTAL CARGO-HANDLING COSTS

				Mechanized Terminal			Unmechanized Terminal		
Annual Throughput ST	Inbound Ratio %	Pallet Ratio %	Plane-Plane Ratio %	New York $/ton	Montreal $/ton	Δ $/ton	New York $/ton	Montreal $/ton	Δ $/ton
5,000	61	25	50	49.40	43.70	5.70	56.30	49.20	7.10
		25	25	49.70	43.80	5.90	55.90	47.80	8.10
		50	50	43.50	39.00	4.50	46.00	40.00	6.00
		50	25	40.50	36.40	4.10	47.30	40.80	6.50
	48	25	50	48.30	42.80	5.50	54.90	47.00	7.90
		25	25	49.40	43.60	5.80	55.80	47.70	8.10
		50	50	43.20	38.70	4.50	46.10	39.90	6.20
		50	25	40.60	36.40	4.20	46.90	40.40	6.50
25,000	61	25	50	43.50	37.30	6.20	47.80	40.00	7.80
		25	25	44.40	38.00	6.40	48.80	40.70	8.10
		50	50	38.90	33.60	5.30	40.70	34.10	6.60
		50	25	36.50	31.60	4.90	41.50	34.70	6.80
	48	25	50	44.00	37.80	6.20	47.90	40.00	7.90
		25	25	45.00	38.50	6.50	48.80	40.60	8.20
		50	50	39.00	33.70	5.30	40.70	34.20	6.50
		50	25	36.70	31.80	4.90	41.40	34.70	6.70
37,500	61	25	50	39.60	34.40	5.20	43.50	36.70	6.80
		25	25	40.70	35.30	5.40	44.50	37.50	7.00
		50	50	35.20	30.80	4.40	36.80	31.30	5.50
		50	25	33.20	29.30	3.90	37.60	31.90	5.70
	48	25	50	40.20	34.90	5.30	43.80	36.90	6.90
		25	25	41.00	35.50	5.50	44.60	37.50	7.10
		50	50	35.40	31.00	4.40	36.80	31.30	5.50
		50	25	33.60	29.50	4.10	37.50	31.80	5.70
50,000	61	25	50	36.40	31.90	4.50	40.10	34.00	6.10
		25	25	37.60	32.80	4.80	41.20	34.90	6.30
		50	50	32.20	28.50	3.70	33.70	28.90	4.80
		50	25	30.60	27.20	3.40	34.60	29.50	5.10
	48	25	50	37.00	32.30	4.70	40.40	34.20	6.20
		25	25	38.00	33.10	4.90	41.30	34.90	6.40
		50	50	32.40	28.70	3.70	33.90	29.00	4.90
		50	25	31.00	27.40	3.60	34.60	29.60	5.00
100,000	61	25	50	32.50	28.30	4.20	36.00	30.50	5.50
		25	25	33.60	29.20	4.40	37.00	31.30	5.70
		50	50	28.50	25.20	3.30	30.00	25.70	4.30
		50	25	27.40	24.20	3.20	30.80	26.30	4.50
	48	25	50	33.00	28.80	4.20	36.40	30.80	5.60
		25	25	34.00	29.50	4.50	37.20	31.40	5.80
		50	50	28.90	25.50	3.40	30.30	25.90	4.40
		50	25	27.70	24.50	3.20	30.90	26.40	4.50

H

Mechanization has a significant impact on costs, ranging from 6 to 15 per cent, depending on the circumstances.

Montreal has a significant advantage over New York. The cost savings range from \$3 to \$8 per ton, or between 12 to 17 per cent. These savings assume that New York and Montreal operate under like circumstances. Therefore, it may be possible to increase Montreal's cost advantage since the circumstances may not be comparable.

Figure 21 presents the range in costs at Montreal and New York as a function of throughput. The highest cost (designated by A in the figure) pertains to an unmechanized system where the inbound ratio is 61 per cent, a plane-plane ratio of 50 per cent and a palletization ratio of 25 per cent. The B systems in the figure are mechanized, have an inbound ratio of 61 per cent, a plane-plane ratio of 25 per cent and a palletization ratio of 50 per cent. The C systems are unmechanized, have an inbound ratio of 61 per cent, a plane-plane ratio of 25 per cent and a palletization ratio of 25 per cent. The D systems are all unmechanized, have an inbound ratio of 48 per cent, a plane-plane ratio of 25 per cent and a palletization ratio of 25 per cent.

Figure 22 presents the maximum and minimum differences between the Montreal and New York terminals as a function of throughput, assuming identical systems. In other words, the greatest cost difference will occur when both terminals operate on a B system.

Figure 21

TERMINAL COSTS
NEW YORK AND MONTREAL

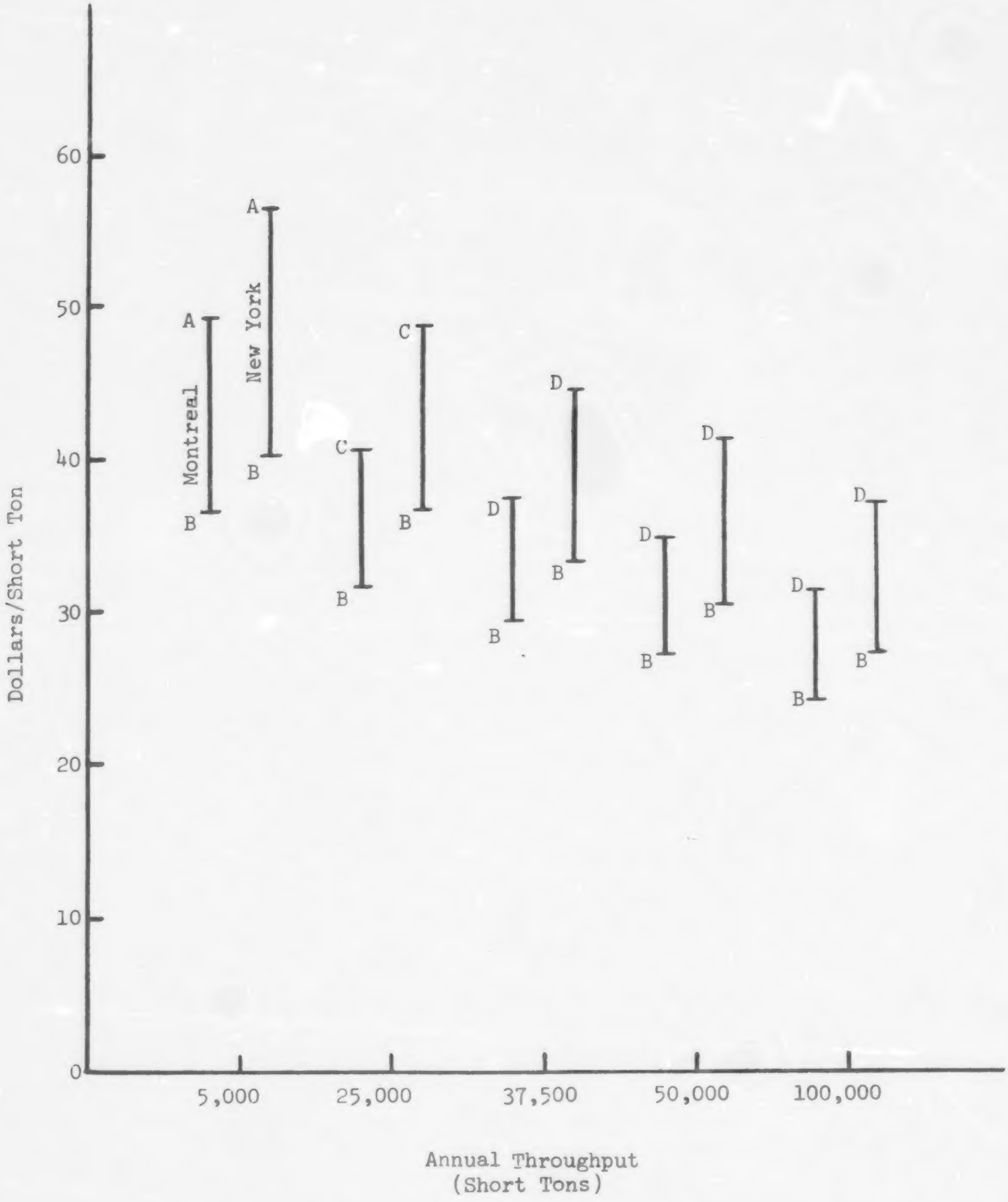
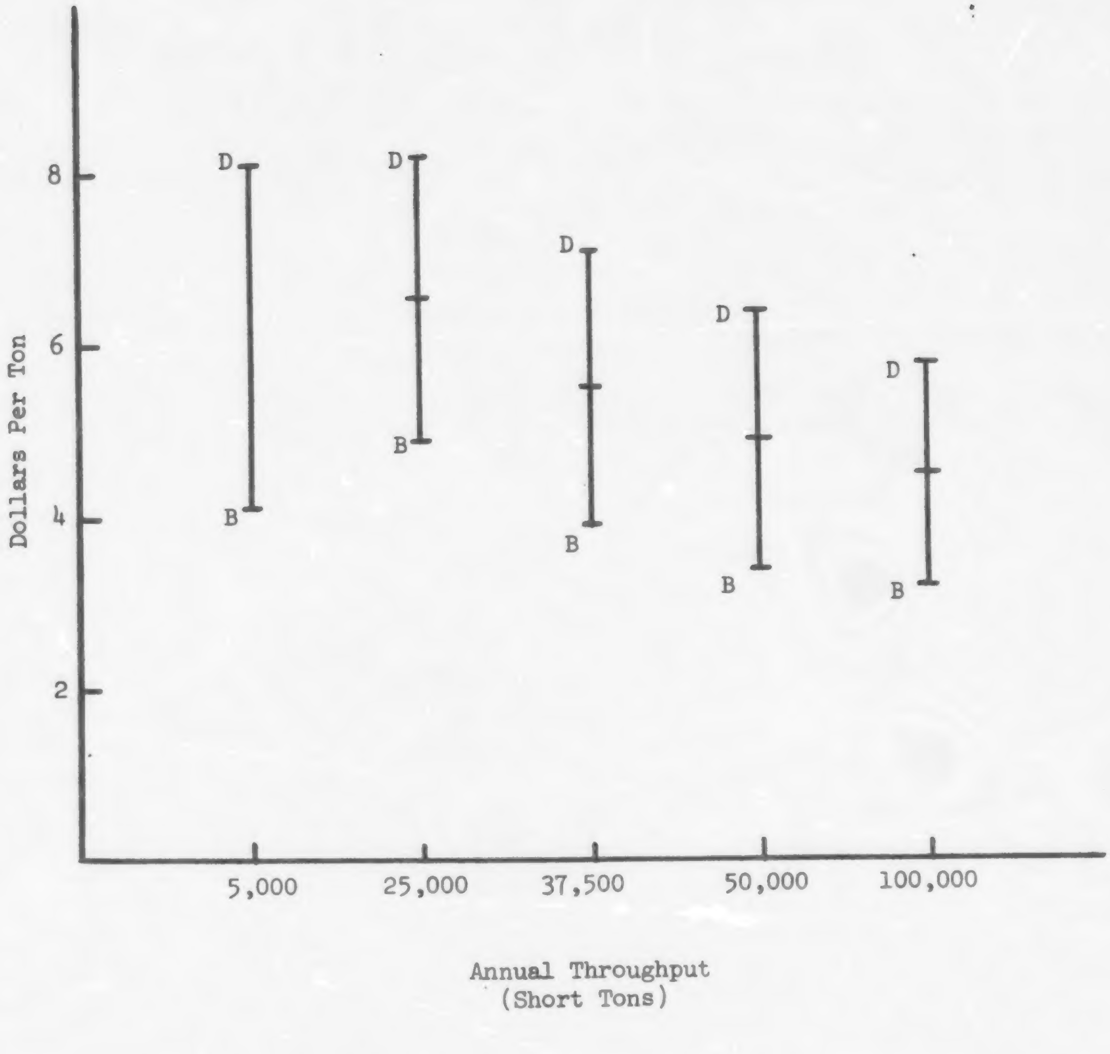


Figure 22

TERMINAL COSTS DIFFERENTIAL



On the average, the difference in Montreal and New York handling costs will be at least $4.40 per ton at annual throughputs of 100,000 tons or more. We expect that the actual difference will be somewhat greater than $4.40 per ton, perhaps as high as $7.00 to $10.00 per ton because New York has many independent terminals, each with relatively small annual throughputs. Therefore, the New York terminals cannot realize the cost reduction associated with high-throughput terminals.

We performed a sensitivity test on labor costs by varying Montreal's total labor costs plus and minus 26 per cent. Total labor costs are a function of basic labor rates and productivity and hence a variation in total labor costs could be caused by changes in either. We chose the value of 26 per cent because an increase of this magnitude in the basic labor rates would put these rates on a par with New York's rates. An increase of 26 per cent in total labor costs increases the cargo-handling costs by $2.50 per ton for a mechanized terminal. The increase ranged from $2.10 per ton to $3.00 per ton. The range in increase at an unmechanized terminal is $2.50 per ton to $3.50 per ton with the average at $3.00 per ton. Therefore, Montreal would still have a cost advantage over New York even with an increase of 26 per cent in labor costs. The advantage will be at least $1.00 per ton and more likely $4.50 to $6.50 per ton.

The analysis of the labor costs assuming a 26 per cent decrease showed that the cargo-handling costs would decrease an average of

$2.60 per ton for mechanized terminals and $3.00 per ton for unmechanized terminals. The range was about $0.50 per ton on either side of the averages.

In summary, annual throughput, the palletization ratio and the degree of mechanization have a significant impact on cargo-handling costs. The inbound ratios and the plane-plane ratios have a negligible impact on cargo-handling cost. Montreal should realize a cost advantage of at least $4.40 per ton, and most likely the advantage will be $7.00 to $10.00 per ton; this higher range was used in determining Montreal's market capture.

Feasibility Analysis

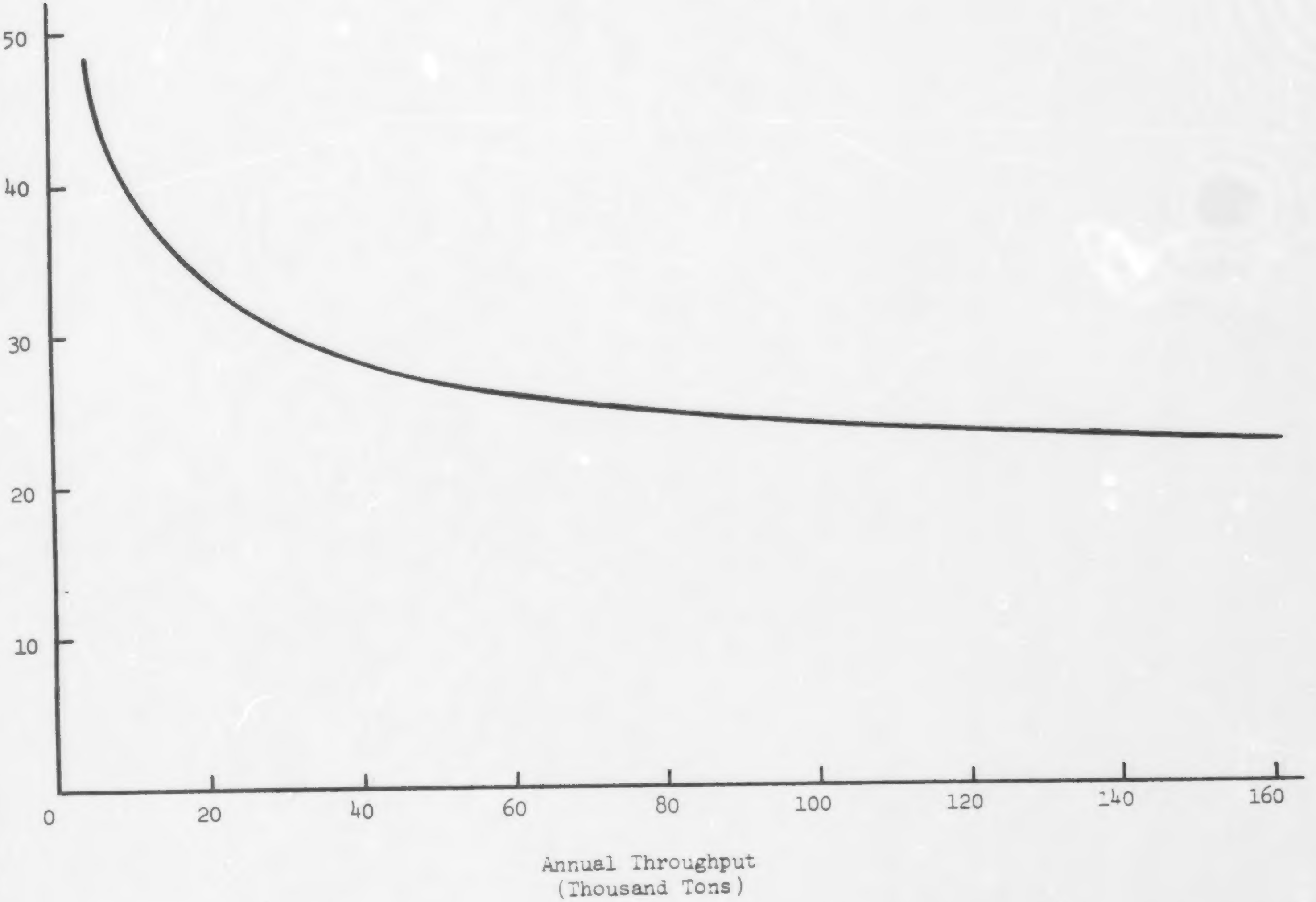
It is obviously impossible to accurately determine the economic feasibility of an air freight terminal at the new Montreal airport without a comprehensive study of competing air freight terminals, competing modes of transportation, future passenger movements and the long-range plans of individual airlines. However, strong indicators of the economic feasibility can be developed using data presented in this and the preceding chapters.

Minimum terminal size

Figure 23 presents cargo-handling costs at the Montreal airport as a function of annual throughput. The data presented in this figure represent the minimum costs presented in Table 29. These costs are not accurate estimates of the costs that Montreal would actually experience

Figure 23

MONTREAL CARGO-HANDLING COSTS



because the inbound ratio, pallet ratio, plane-plane ratio and degree of mechanization will undoubtedly be different from the values assumed in Table 29. However, we can treat these costs as representative of the cost that Montreal would actually experience. Based on the data presented in Figure 23, we can state that the terminal will be economically viable if the annual throughput is greater than about 80,000 tons per year since the curve is relatively flat for throughputs greater than this value. The cargo-handling costs would be about $25 per ton at a throughput of 80,000 tons per year. If the annual throughput were doubled, the minimum cargo-handling costs of about $23 per ton would be achieved.

Transportation costs via Montreal

If we assume that domestic and transborder air cargo to and from Montreal, Quebec City and Ottawa will use the new Montreal airport, the airport will have a throughput of 100,600 tons per year in 1975 (based on average forecasts) -- well above the 80,000-ton limit for economic viability. Given a base throughput of 100,600 tons in 1975, the basic question is whether or not Montreal would be successful in attracting significantly more cargo, and the principal source for additional cargo is the cargo moving in the North Atlantic service. Two cases must be analyzed in order to answer this question:

1) Toronto is not a major air center for European air cargo
2) Toronto is a major air center for European air cargo

A basic assumption in this analysis is that the air cargo will move through one of the following major air centers if it does not move through Montreal:

Chicago
Detroit
Kansas City
Minneapolis/St. Paul
New York
Toronto

The European air cargo to and from Montreal, Quebec City and Ottawa will move through New York if not Montreal, as New York is the closest major air center (assuming Toronto is not a major air center for European air cargo). The differential costs of serving these cities via New York will be the New York cargo-handling costs plus added aircraft costs plus truck costs for the movement between New York and these cities Using the data in Table 29, we have estimated minimum cargo-handling costs in New York to be about $25 per ton (at 160,000 tons per year). This estimate is very optimistic as it assumes a centralized (common-user) air terminal and New York actually has many proprietary terminals and the average costs will be somewhat higher than the $25 value. New York is about 180 miles further from European cities than is Montreal. A typical air freighter costs about $1,000 per hour, averages about 500 miles per hour and 25 tons per flight. The added aircraft cost of serving New York as opposed to Montreal is about $14 per ton. Assuming truck costs are $0.05 per ton-mile, the differential costs of serving Montreal, Quebec and Ottawa become:

	Via Montreal $/ton	Via New York $/ton	Savings $/ton
Montreal	25	59	34
Quebec	33	67	34
Ottawa	31	60	29

The "via Montreal" costs assume $25 per ton for cargo handling and $0.05 per mile for trucking. If the cargo were to move on passenger aircraft (instead of freighters) the costs of service via New York would be reduced about $7.00 per ton.

In a similar manner, we estimated the savings that cargo moving between Europe and other CMA's and SMSA's would realize by using Montreal instead of the competing air center. The results of this analysis appear in Table 30. The savings are based on comparing the costs of like aircraft -- that is, the savings shown for freighter aircraft are based on the assumption that the cargo moves on freighter aircraft regardless of the air center used.

We made several conservative assumptions in developing these savings shown in Table 30. First, we assumed that the cargo-handling cost at Montreal was $25 per ton. Second, we assumed that the cargo-handling cost at all U.S. air centers was $25 per ton. Third, we assumed that the cargo-handling cost at Toronto was $23 per ton. The Montreal cargo-handling cost should be at least $1.00 to $2.00 lower than the value

Table 30

SAVINGS AT MONTREAL
(Dollars Per Ton)

CMA or SMSA	Competing Air Center	Annual Tonnage*	Savings Realized Freighter Aircraft	Savings Realized Passenger Aircraft
Without Toronto As Major Air Center				
Toronto	Detroit	23,600	35	17
Quebec City	New York	3,300	34	27
Montreal	New York	23,300	33	26
Ottawa	New York	3,600	29	22
Hamilton	Detroit	5,600	24	6
Syracuse	New York	5,700	14	7
Buffalo	New York	16,800	13	7
Albany	New York	7,200	10	3
Saskatoon	Minneapolis	1,400	10	0
Boston	New York	11,600	9	2
Winnipeg	Minneapolis	3,500	2	1
Edmonton	Minneapolis	3,100	0	0
Calgary	Minneapolis	2,700	- 2	- 1
Regina	Minneapolis	1,400	- 4	- 2
Erie	Detroit	2,500	-30	-34
Kitchener	Detroit	2,400	-33	-30
London	Detroit	2,100	-37	-41
Cleveland	Detroit	28,100	-41	-41
Windsor	Detroit	3,100	-49	-49
Cincinnati	Detroit	19,900	-50	-44
With Toronto As Major Air Center				
Quebec City	New York**	3,300	34	26
Montreal	New York**	23,300	33	26
Ottawa	Toronto	3,600	26	15
Syracuse	New York	5,700	14	7
Albany	New York	7,200	10	3
Saskatoon	Minneapolis	700	10	0
Boston	New York	11,600	9	2
Buffalo	Toronto	8,400	3	- 6
Winnipeg	Minneapolis	1,800	2	1
Edmonton	Minneapolis	1,500	0	0
Calgary	Minneapolis	1,300	- 2	- 1
Regina	Minneapolis	700	- 4	- 2
Cincinnati	Detroit	10,000	-50	-44

* 1975 average forecasts (see Tables 17 and 19).

** Toronto is competing air center when passenger aircraft are used.

used as throughput increases above 80,000 tons per year. The U.S. air center costs were based on the assumption that the terminal throughput would be about 160,000 tons per year. Actually, U.S. air centers have many proprietary terminals, each capable of handling 20,000 to 80,000 tons per year. The cargo-handling costs at these terminals would be between $27 and $36 per ton. The estimated Toronto cargo-handling costs were based on the estimated Montreal cost at an annual throughput of 160,000 tons per year. This implies that the Toronto facility is a common-user terminal rather than a series of proprietary terminals. Further, Toronto costs should be higher than Montreal's because labor costs are higher. Therefore, we have probably underestimated the savings realized by using Montreal and therefore the values presented in Table 30 can be considered as the minimum savings.

European air cargo moving to and from the CMA's and SMSA's listed in Table 30 that could use New York or Toronto as a competing air center will experience a significant cost reduction by moving through Montreal. European air cargo to and from Toronto and Hamilton (assuming that Toronto is not a major air center) will also realize a significant cost reduction by using Montreal. As a result, Montreal should not have any difficulty in attracting this cargo.

Minneapolis/St. Paul is potentially the lowest-cost air center for the western CMA's listed in Table 30. (European cargo to and from these CMA's will be transshipped by air, regardless of the air center used.)

If the savings were adjusted according to the discussion above, all cargo would realize a slight reduction in costs by moving through Montreal instead of Minneapolis/St. Paul. Since it is doubtful that there will be adequate service between the CMA's and Minneapolis/St. Paul or between Minneapolis/St. Paul and Europe, the competing air center would probably be Chicago, hence increasing the savings realized by using Montreal.

The real challenge will be to attract European cargo to and from Erie, Kitchener, London, Cleveland, Windsor and Cincinnati to Montreal. These CMA's/SMSA's can be served from Detroit by truck, whereas the cargo must be transshipped by air if served from Montreal. Montreal cannot compete for this cargo if Detroit has frequent nonstop service to Europe. We indicated in the previous chapter that Detroit will not have sufficient belly capacity to move the European air cargo moving through Detroit and we further indicated that New York will probably remain a major transshipment port for air cargo. If we were to assume that Detroit did have frequent nonstop service to Europe and further assumed that some cargo from these CMA's/SMSA's moves to Europe either by a freighter aircraft that traveled partly full from Detroit to New York and then to Europe or by passenger aircraft to New York, then transshipped to a Europe-bound passenger aircraft, the costs would increase to the point where substantial savings could be realized by shipping the cargo through Montreal. Consider the following examples for Cleveland cargo moving to Europe:

Case 1	Domestic passenger aircraft Cleveland to New York, transship; passenger aircraft New York to Europe
Case 2	Truck Cleveland to Detroit; freighter aircraft Detroit to New York (half full); freighter aircraft New York to Europe (no transshipment)
Case A	Passenger aircraft to Montreal, transship; passenger aircraft Montreal to Europe
Case B	Freighter aircraft Cleveland to Montreal, transship; passenger aircraft Montreal to Europe
Case C	Passenger aircraft Cleveland to Montreal, transship; freighter aircraft Montreal to Europe
Case D	Freighter aircraft Cleveland to Montreal, transship; freighter aircraft Montreal to Europe

The differential costs of the various combinations of cases were developed using the same cost elements used in the analysis described. The savings realized by using Montreal instead of the competing air centers are presented below in dollars per ton:

	Case A	Case B	Case C	Case D
Case 1	5	-12	-102	-119
Case 2	120	103	13	- 4

The purpose of this example is to illustrate the fact that Montreal can capture cargo if the competing air center does not provide sufficient direct service.

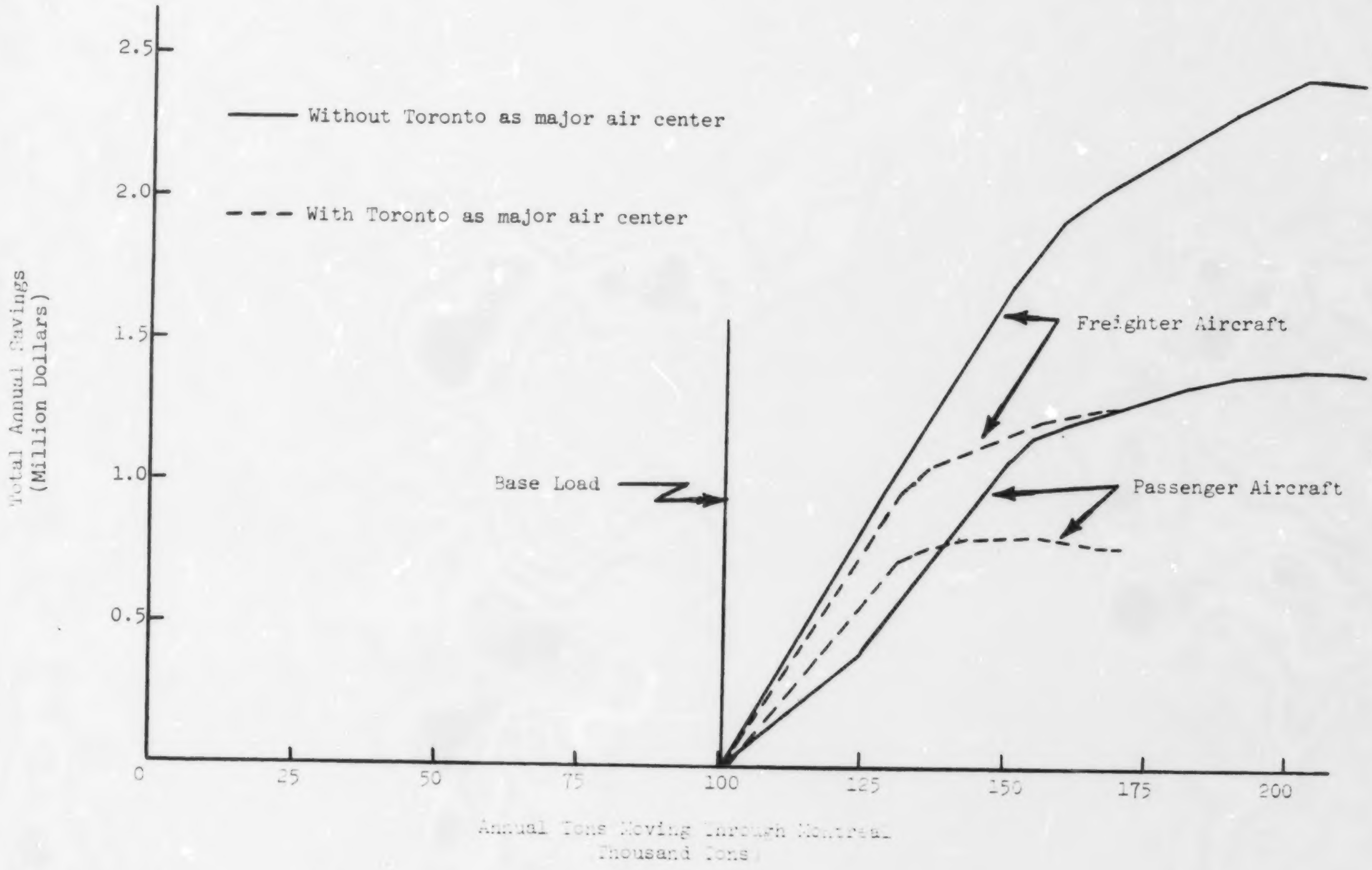
The total annual savings that would be realized by routing European cargo through Montreal are presented in Figure 24. The total annual savings realized by using the new Montreal airport would be about $2,000,000 if Toronto does not become a major air center for European cargo and about half this value if Toronto does become a major air center. If Montreal is successful in attracting cargo from Detroit, these savings will probably increase significantly. The total savings presented in Figure 24 are the "minimum" savings obtainable as per the discussion above.

Based on the fact that the annual throughput will be well above the minimum economically viable "limit" of 80,000 tons and the fact that the new terminal would lower transportation costs by as much as $2,000,000 annually, we conclude that the terminal will be economically viable.

The above analysis considered all the area pair movements presented in Tables 24 and 28 except for the tonnage moving between the U.S. and eastern CMA's. As this cargo amounts to less than 6,000 tons annually, the annual savings will not change significantly.

Figure 24

TOTAL SAVINGS REALIZED*



*Total savings realized by routing air cargo through Montreal instead of competing air center considering differential air and surface distances and costs as well as cargo handling costs.

Congestion and delays

The above analysis does not consider congestion or other delays such as those that may be experienced at border crossings because of customs. A recent study* indicates that the New York and Chicago airports experienced delays of twenty minutes to one hour during peak hours in 1969 and estimates that the peak-hour delays will grow to more than two hours by 1981. The study further estimated that 21 other airports will have peak-hour delays greater than twenty minutes by 1981. The marginal costs (crew and fuel) of keeping a DC-8-63F aircraft aloft is about $500 per hour. Assuming the average delay at New York will be half an hour in 1975, the costs of moving cargo through New York (and Chicago in the case of the western CMA's) will increase about $10 per ton. Detroit will also experience some delays in 1975, probably about five minutes on the average.

If European air cargo to and from the various CMA's does not move through Montreal, the cargo will experience delays at border crossings. A line-haul truck costs about $22 per hour and should carry about ten tons of air cargo each trip. An hour's delay will therefore increase the costs of using U.S. CMA's about $2.00 per ton.

We have assumed that the Montreal airport will have a customs facility and European and Canadian cargo moving to the U.S. will clear customs in Montreal and travel in bond to the border. Therefore, U.S. cargo moving through Montreal should not be subjected to delays at border crossings.

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* A statement on National Transportation Policy, Department of Transportation (U.S.), 1971.

Montreal airport will not have a curfew limiting operations. Therefore, airlines using Montreal will not be constrained in scheduling arrivals and departures and hence should realize increased aircraft utilization. The increased utilization will in effect lower the costs of moving cargo through Montreal -- perhaps as much as $10 to $20 per ton.

If we consider the additional savings obtainable due to our conservative estimates of cargo-handling costs, add the savings due to congestion in New York, delays at border crossings and the savings due to increased aircraft utilization when Montreal is used, the total annual savings will be about $4,000,000 if Toronto is not a major air center for European air cargo and about $3,000,000 if Toronto is a major air center. These savings assume that Erie, Kitchener, London, Cleveland, Windsor and Cincinnati cargo does not move through Montreal and that the cargo to and from the western CMA's move through Chicago instead of Minneapolis/St. Paul. However, these additional savings increase the possiblity that European cargo to and from these CMA's/SMSA's will move through Montreal.

The annual savings that will be realized by using Montreal will range from $2,000,000 to $4,000,000 if Toronto does not become a major air center for European air cargo and from $1,000,000 to $3,000,000 if

Toronto does. The lower limits of these ranges represent readily identifiable, direct savings, the upper limit includes intangible savings resulting from reduced delays, increased utilization, etc.

Revenue and charges

The potential savings will be most likely realized by the airlines. IATA sets air cargo tariffs, and the current tariff structure does not make allowances for different "ports of entry." The tariff from Europe to Cleveland, for example, is equivalent to the rate to New York plus the minimum rate from New York to Cleveland and this rate applies if the cargo is transshipped at New York or Montreal. Therefore, the customers will probably not share in the savings realized by routing cargo through Montreal.

The operator of the common-user terminal at the new Montreal airport will have to negotiate with the airlines to determine the cargo-handling charges (that is, the unit revenues for the terminal). Our estimate of cargo-handling cost include an allowance for 15 per cent return on investment after taxes. Accordingly, the terminal operator will realize a return on investment greater than 15 per cent after taxes if the negotiated charges are above the curve presented in Figure 23.

Service frequency and sensitivity

Service frequency, up to a point, is an important factor in attracting air cargo to the new Montreal airport, particularly European air cargo. We feel that five flights between any pair of origins and destinations is adequate and if a major air center has more than five flights per week to a particular destination, factors other than service frequency will govern the shipper's selection of routes (air centers used). The major air centers will have the following number of passenger flights per week to Europe in 1975 (See appendix table E-3):

New York	520
Montreal	160
Chicago	130
Detroit	35

Many of these flights will call at more than one foreign destination. New York certainly will have adequate service frequency in passenger aircraft alone. Montreal and Chicago will have adequate frequency to major European air centers but probably not to the minor air centers. Detroit will have adequate service frequency to only a few European air centers with passenger aircraft. These conclusions are verified by analysis of westbound passenger flights early in 1972. New York had service from 34 European cities and only Belgrade, Dusseldorf and Gothenburg had less than five flights per week. Montreal had service from 17 European cities and only Cologne, Dublin, Milan and Vienna had less than five flights per week. Chicago had service from ten European cities and three of these cities, Athens, Shannon and Zurich, had less than five flights per week. Detroit had service from four European cities and only Amsterdam and London had five or more flights per week. We are projecting a significant increase in passenger flights to and from Montreal by 1975 and consequently the number of European cities that will have more than five flights per week will also increase. We feel that Montreal will have adequate service to most, if not all, European air centers by 1975 when passenger and freighter flights are considered. The European air centers that may not have adequate service will be minor centers with small amounts of tonnage, and any reduction in Montreal's throughput will be negligible.

Air cargo in domestic and transborder services to and from the Montreal region will not be as sensitive to service frequency as cargo moving to and from Europe since Montreal will be the origin or destination of the cargo. In any event, we believe there will be a high level of service because of the quantity of cargo moving.

The analysis of the savings was conservative in that we underestimated the differential cargo-handling costs by about $5.00 per ton. Nevertheless, an analysis of the data presented in Table 30 indicates that market capture is not particularly sensitive to cargo-handling costs. For example, consider the European tonnage that will move through Montreal assuming Toronto does not become a major air center. If the air cargo moves by air freighter, 105,600 tons will move through Montreal with positive direct savings -- that is, all cargo to and from

CMA's/SMSA's appearing above Edmonton in the table. If the cargo-handling costs at Montreal were increased from $25 per ton to $30 per ton (a 20 per cent increase), 102,100 tons will still have positive direct savings (a 3 per cent reduction in tonnage). The largest relative reduction occurs under the assumption that Toronto becomes a major air center and the cargo moves on passenger aircraft. In this case, a 20 per cent increase in cargo-handling costs will cause a 36 per cent reduction in tonnage, realizing positive direct savings. However, this cargo has the alternative of moving through New York or Chicago (assuming Minneapolis/St. Paul does not have adequate service) and would have indirect savings (due to congestion, delays, etc.) of about $20 per ton if it moves through Montreal. Therefore, we do not believe that significant amounts of cargo will be lost if we have underestimated cargo-handling costs in Montreal. An understatement in cargo-handling cost, however, will significantly affect the total annual savings. A 20 per cent increase in cargo-handling cost will lower the total annual savings between $250,000 and $400,000, depending on Toronto's status as a major air center. A reduction in savings of this order of magnitude does not change the conclusions of the economic feasibility of the terminal.

It has been suggested that the location of a distribution center in the immediate vicinity of the airport may induce some additional volumes at the air cargo center. This induced volume will be small, certainly in the early stages of development. The distribution center will attract more consumer product-oriented business than those concerned with industrial products. The induced volume would arise if companies marketing high-value air-prone products who use the distribution center choose Montreal as a distribution center for North America or at least for northeastern North America. This choice depends on the geographical pattern of sales as well as on the costs of operation at Montreal. If the company's sales follow population patterns or value-added patterns, then the New York metropolitan area (or the Chicago area) has advantages that would be difficult to overcome on the basis of handling costs and storage cost savings.

One should also consider another form of induced volume -- originating from the exports of Canadian companies. Canadian companies who use the distribution center for distribution in Montreal and Quebec Province may find it attractive to ship air cargo exports from the distribution center. However, much of this traffic already moves through Montreal (certainly for North Atlantic exports) and might continue to do so in any event. The greatest potential for induced air cargo volume therefore must come from the establishment of Montreal as a market center for a portion of U.S. North Atlantic imports. We cannot see this happening until the users recognize the importance of Montreal as an air cargo center.

Aggressive marketing activity

We have suggested that the Quebec Government establish an aggressive marketing activity to increase the flow of cargo through the new Montreal airport. There are six specific areas where the marketing activity is required.

The Quebec Government must work with the federal government and the airlines to establish the necessary landing rights in European air centers and the SMSA's in the U.S. and to provide adequate service frequency to these areas. This activity will be particularly important in capturing the second-level European air cargo such as cargo moving to and from Cincinnati (see Tables 17 and 19).

The Quebec Government must work with IATA to obtain rates favorable to Montreal and to allow shippers to realize some of the potential savings.

A U.S. customs center must be established at the new Montreal airport to allow rapid customs clearance. Bonded trucking services must be established to allow rapid and direct service between Montreal and SMSA's in the U.S.

The airlines must be "sold" on the concept of a common-user air freight terminal. This task may be particularly difficult in the face of the consortia of foreign airlines.

A promotional campaign must be established to extol the services provided at the new airport and to convince shippers to route their cargo through Montreal. The airlines will perform the promotional activities but the Quebec Government can provide valuable assistance -- by establishing shipper lists and other statistics, for example.

Finally, a continuous and active long-term planning function must be established if the new airport is to avoid the difficulties in congestion, delay, etc. currently being experienced by major airports in the U.S. Adequate runways, terminal facilities, etc. must be provided as traffic through the airport grows.

Montreal Terminal Requirements

Tables 24 and 26 present the two different levels of 1975 market capture that we believe represent the range of the achievable (prime only and prime plus first and second levels). The information in these tables served as a base to "design" two air cargo terminals. In order to estimate the number of freighter docks required, we made the following assumptions concerning the amount of cargo that will move by all-cargo aircraft:

Market Penetration Level	Prime Only %	Prime Plus First and Second %
Canada/Europe	35	60
Canada/U.S.	25	25
U.S./Europe	-	50
Domestic	25	25

The percentages for the European services are higher than indicated in Table 23 because Table 23 assumes that capacity in the passenger aircraft is distributed among the European cities in the same proportion as the cargo. Since this assumption is not entirely accurate, we increased the air freighter cargo.

When these percentages are applied to the data in Tables 24 and 26 the result is that 32 and 40 per cent of the cargo will move by air freighter at the two levels of market penetration. We assumed that each freighter dock will have a throughput of four aircraft per day and that 50 tons is exchanged per aircraft.* When the prime-only market is considered, one freighter dock will handle as much as 35 per cent of the cargo. We decided that the terminal should have at least two freighter docks since our estimate of 32 per cent is not a precise one and more than 35 per cent could easily move by freighter. Two freighter modules could accommodate as much as 70 per cent of the cargo.

Two freighter docks will accommodate as much as 40 per cent of the air cargo when the prime, first and second levels of market penetration are considered. Once again, we increased the number of freighter docks because of the confidence limits on our estimate of the cargo that will move by freighter. Three modules will accommodate as much as 60 per cent of the air cargo.

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* Based on a stretched DC-8 at 50 per cent utilization.

The data in Table 29 indicates that mechanized terminals will generate lower costs than unmechanized terminals. Therefore, we assumed that the terminals will be mechanized and used the procedures outlined in Appendix F. Assuming that the office space will be on the second floor of the cargo building, a cargo building about 325 x 250 feet will be required for the prime-only market (annual throughput of 210,000 tons) and a building about 600 x 250 feet will be required for the prime plus first and second level (370,000 tons annual throughput).

We used the data in Tables 24 and 26 to estimate the number of truck positions using the same procedure described earlier in this chapter. Twenty truck positions will be required at the lower market level and 26 at the higher. This allows 16 feet per position in the smaller building and 23 feet per position in the larger. These spacing figures emphasize the necessity to develop the truck position requirements in detail. Using the same approach and assuming each truck carries an average of 5 tons, an average of 120 trucks will call at the smaller terminal per day and an average of 160 trucks will call at the larger. If a truck both discharges and loads cargo at the terminal, the number of truck calls will be reduced accordingly.

Montreal Terminal Costs

We followed the procedure outlined in Appendix F to estimate the terminal costs for the two markets described in Tables 24 and 26 (the prime market only and the prime plus first and second levels of market penetration), assuming that the terminal would be mechanized and that 25 per cent of the cargo would move through the terminal on pallets. We made the first assumption on the basis of the results presented in Table 29. A 25 per cent palletization ratio is a little higher than current experience in air transportation but probably a realistic value for the type of service and markets that will use the new Montreal airport in 1975. We also assumed the recommended freighter dock loading module described in Figure 18 rather than the more conventional transporter-elevator system of loading and unloading. The terminal costs are estimated to be $27.10 for the prime market only (208,700 tons annually) and $25.90 for the prime plus first and second levels of market penetration (366,200 tons annually). These costs include labor, overhead, equipment costs and land rent, airport tonnage charges, and an allowance for profit of 15 per cent return on investment after taxes. These costs do not include the cost of the auto or truck parking areas. Tables 31 and 32 summarize the investment and annual costs of these terminals.

We estimate that the smaller terminal (prime market only) will employ a total of 300 people (including security staff), 200 of whom will work on the average day. The larger terminal will employ a total of about 510 people, 340 of whom will work on the average day. Assuming that a maximum of 75 per cent of the employees will be on the premises at the same time (during shift breaks) and that the

Table 31

TERMINAL COSTS
PRIME MARKET ONLY
(Dollars)

Investment:		
Cargo building		2,582,300
Freighter dock building @ $780,000 ea.		1,560,000
Truck loading apron, paving		72,800
Equipment		
Cargo building	1,725,700	
Freighter docks	1,391,700	3,117,400
Total		7,332,500
Annual Costs:		
Rent		23,100
Labor		
Work force	2,359,600	
Security force	223,800	2,583,400
Cost of capital		
Cargo building	759,200	
Freighter docks	458,600	
Truck loading apron	21,400	
Equipment	998,300	2,237,500
Maintenance and repair		
Cargo building	38,700	
Freighter docks	23,400	
Truck loading apron	1,100	
Equipment	304,100	367,300
Insurance and taxes		
Cargo building	64,600	
Freighter docks	39,000	
Truck loading apron	1,800	
Equipment	77,900	183,300
Tonnage fees		266,100
TOTAL		5,660,700

Table 32

TERMINAL COSTS
PRIME AND FIRST AND SECOND LEVELS
(Dollars)

Investment:		
Cargo building		4,436,700
Freighter dock building @ $780,000 ea.		2,340,000
Truck loading apron, paving		127,600
Equipment		
Cargo building	3,113,400	
Freighter docks	2,087,500	5,200,900
Total		12,105,200
Annual Costs:		
Rent		39,300
Labor		
Work force	3,986,500	
Security force	392,800	4,379,300
Cost of capital		
Cargo building	1,304,400	
Freighter docks	688,000	
Truck loading apron	37,500	
Equipment	1,665,800	3,695,700
Maintenance and repair		
Cargo building	66,600	
Freighter docks	35,100	
Truck loading apron	1,900	
Equipment	508,600	612,200
Insurance and taxes		
Cargo building	110,900	
Freighter docks	58,500	
Truck loading apron	3,200	
Equipment	130,000	302,600
Tonnage fees		466,900
TOTAL		9,496,000

terminals provide parking for two-thirds of this number, then 100 and 170 parking spaces will be required for the small and large terminals respectively. In each case, the end line of the parking area will be located about at the end of the building assuming that the parking area is developed for the full 88-foot width.

If we assume that the terminal operator has a fleet of pickup and delivery vehicles capable of moving all loose cargo in the Montreal, Ottawa, Quebec City region, about 50 vehicles will be required for either level of market penetration and between 12,000 and 21,000 square feet of parking space will be required, depending on parking pattern (block stow versus random access).

If the land rent and the paving costs for the auto and truck parking areas are charged to the cargo operations, the costs would increase by less than $0.15 per ton.

If we assume that the number of truck positions or the spacing between the positions at the cargo building is inadequate and further assume that 30 feet per position (or the equivalent increase in the number of positions) are required, the cargo building would be 600 x 250 feet for prime-only market and 780 x 250 feet for the prime plus first- and second-level market. If buildings of these dimensions are required, the terminal costs increase by $2.60 per ton for the smaller market and $1.10 per ton for the larger.

We assumed that the terminal would be a common-user facility in calculating the costs presented above. If we assumed that the terminals were operated by eight airlines, each with equal throughputs totaling 366,200 tons and assuming each operator had a single freighter dock module, the cost would increase to about $38 per ton (as compared to the cost at $25.90 per ton presented above). This increase is caused by the increased total in space requirements of many operators as opposed to one operator. A cargo building 800 feet long would be required for the eight operators. Most of the additional space is in the freighter dock modules. If the cargo buildings were operated by eight airlines in a proprietary manner but the freighter dock were a common-user facility, the costs would be about $32 per ton.

Summary

We have reviewed the general plans for the terminal area and made several minor suggestions for improvements. There is one aspect of the general design that requires additional research -- the number of truck loading and unloading positions available along the building. We feel that the number of positions offered by the current design is marginally adequate. The number of positions required is a function of the proportion of the cargo moving through the terminal on pallets and the average load carried by pickup and delivery vehicles, which in turn influence the overall productivity of each position. If additional research indicates a higher proportion of cargo moving on pallets or a higher overall productivity for the truck positions, the number of positions may be adequate. If the number of positions is not adequate, one of the alternatives available would be to make the building narrower, thereby increasing the number of positions per square foot of terminal area.

We have analyzed the variables which influence the terminal costs in Montreal and New York. As a result of this analysis we have concluded that Montreal costs will be at least $4.00 per ton lower than New York and that the saving is probably closer to $7.00 to $10.00 per ton. These savings will influence Montreal's share of the air cargo market.

We favor a finger-pier loading module as opposed to the more convential method of using transporters and elevators and working in the open. The finger pier will have a higher productivity and protect the cargo and cargo handlers from the elements.

We analyzed Montreal's terminal requirements and costs for two levels of market penetration in 1975. The larger terminal, for the prime plus first- and second-level penetration (Table 23 -- assuming that Toronto is not an international airport) will require three loading modules and a cargo building between 600 and 780 feet long, and the costs will range between $25.90 and $27.00 per ton, depending on the number of truck loading positions. The smaller terminal, for the prime market only (Table 26 -- assuming that Toronto is not an international airport), will require two loading modules and a cargo building between 325 and 600 feet long, and the costs will range between $27.10 and $29.70

per ton. The building sizes and cargo-handling costs for the prime, first and second levels of market penetration assuming that Toronto becomes a major international airport (Table 27) will be about the same as the estimates generated assuming that Montreal captures the prime market only and Toronto is not a major international airport.

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IV. DISTRIBUTION CENTER

Much of the effort and research in distribution has centered on transportation and inventory management. While these subjects are important to shippers and consignees, they only treat part of the problem of distribution. The major economic and operational problems leading to generally poor service on intermodal shipments, and the poor service and high rates for small shipments and high costs to small shippers, may be viewed as problems of economies of scale. By definition, small shipments and small shippers imply a small scale of operation at one or both ends of the distribution chain. Further scale problems are introduced by the small scale of operations at carrier terminals and intermodal or interline exchange points. Even a small city will have many terminals, generally one for each carrier serving the area. Low throughput at each terminal and low vehicle utilization in local drayage lead to high costs and poor service. A distribution organization, located at or near the new Montreal airport, operating under one management and serving many small-scale shippers could provide economies of scale which would result in lower overall distribution costs for these shippers. The organization could offer a full range of distribution and intermodal services.

The only example of a distribution center of the type envisaged in this study is not yet in operation. NDC (National Distribution Corp.) was formed over a year ago by Eastern Airlines, North American Rockwell and Parsons to operate distribution centers in the United States. Five centers are scheduled to be operational in June 1973. There has been little in the press since June 1972 and specifications, services, price lists, etc. are not available; nor has any information on operating procedures and organizational structure been released.

NDC will offer a broad range of storage, forwarding and distribution services from centers in New York, Chicago, Los Angeles, Atlanta and Dallas. While preliminary literature indicated that NDC would offer cartage services no ICC application has been reported. We have found no published statement on the NDC site locations. In the absence of such reports it is possible that NDC will not meet the June 1973 date.

The only other general distribution centers are associated with warehouse companies (for example, Overmeyer) which operate networks of public warehouses. Several railroads operate distribution centers for appliances, or for grocery products. These railroad centers are generally used to reload railcars to obtain full carloads of mixed products for destinations. They are not inventory centers or product transportation centers.

This chapter discusses the following characteristics of such a distribution company:

1) Potential users
2) Distribution center services
3) Market potential

4) Distribution center costs
5) Transportation interface
6) Organization and controls
7) Feasibility analysis

A summary discussion is presented as the last section of this chapter.

Potential Users

The distribution company acts as agents for, and is responsible to, clients who own the goods. The clients may be either shippers (producers) or consignees (receivers) who are located in the Montreal region or not, and the goods may move in international or domestic trade.

We believe that the largest group of clients, both in number and tonnage, will be those engaged in domestic movements. Further, most of these clients will be shippers located outside of the Montreal region serving markets in the Montreal region. Distribution centers tend to be located in the consumption areas in order to minimize delivery time and transportation costs. The goods stored in a distribution center are more often owned or controlled by the shipper than the consignee because shippers generally have larger inventories than consignees and hence have lower unit costs. It is interesting to note that NDC, Inc. does not envisage having consignees as principal clients.

Clients with cargo moving in foreign trade can be grouped into six origin/destination classes:

U.S. to Canada

Canada to U.S.

Foreign* to Canada

Foreign to U.S.

Canada to foreign

U.S. to foreign

We expect that the Montreal distribution center will have a significant number of clients in the U.S.-to-Canada trade and we further expect that the majority of these clients will be shippers for the reasons stated above. These shipper clients will use the Montreal distribution center to serve the Montreal region and perhaps eastern Canada.

Cargo moving from Canada to the northeastern U.S. (Region C in Figure 7) may use the Montreal distribution center, particularly if the new Montreal airport is successful in attracting North Atlantic air cargo to and from this region. Presumably, if the airport is successful in attracting the North Atlantic air cargo, a transportation network (system) operating between the cities in Region C and Montreal will be established and this network could also be used to carry Canadian cargo from the distribution center. Once again, we believe the majority of the cargo moving from Canada to Region C will be under the shipper's control rather than the consignee's control. We do not believe that a distribution center located in Montreal will be successful in attracting appreciable amounts of Canadian cargo destined to the U.S., other than Region C, on the grounds that distribution centers tend to be located in the consumption area.

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*Foreign as used here refers to foreign commerce other than with the United States.

We doubt that the distribution company would have a significant amount of business, both in numbers of customers and tonnage, involving cargo moving from Canadian or U.S. origins to foreign locations (for example, Europe), because the economic advantages would be small if they existed at all. Shipments of this type would probably use a foreign distribution center. We do foresee, however, an appreciable market for foreign cargo destined to Canadian and U.S. locations. The distribution company could increase its penetration into this market if the center were located in a free-port area and if the company provided auxiliary services such as packaging and marking. The principal advantage of the free-port location is that payment of Canadian duties is delayed until the cargo leaves the center for Canadian customers and avoided altogether for cargo moving to U.S. customers. If auxiliary services (such as marking or packaging) are also provided, the goods could be made ready for the eventual consignees in a free-port location, thereby reducing property taxes. The free-port concept will require a bonded warehouse and probably advance arrangements for customs clearance, particularly with U.S. Customs. In a sense, the distribution company would act as a customs broker.

In the case of foreign cargo destined for Canadian or U.S. markets, we believe that consignees rather than shippers will be the distribution company's principal clients. The consignees will actually be intermediaries such as wholesalers, and will in fact sell the goods to another organization in the distribution chain and use the distribution center as their warehouse. These consignee clients will obviously serve customers in the Montreal region and Region C of the U.S. Additionally, however, these clients would attempt to extend their market area to include other regions of Canada and the U.S. If Montreal is successful in developing as a major transportation hub, it would be the logical port of entry for incoming goods and the consignee's clients may very well be able to extend their market regions to include all eastern Canada and Region A of the U.S. (see Figure 7). Penetration into Region A would, of course, be a function of the competition. In other words, U.S. distribution companies, spurred on by the success of the Montreal distribution center, will probably offer stiff competition. Based on the current trend of transportation costs in the U.S. and Canada and the transocean tariffs between North America and Europe, we believe that a Montreal distribution center will have a slight advantage over its U.S. counterpart in competing for the Region A markets. A Montreal distribution company will probably be at a slight disadvantage in competing for cargo originating at the foreign locations other than Europe.

The distribution company will offer economies of scale to clients who have small-scale operations at both ends of the distribution chain or in a particular geographic area. Companies with large-scale operations would not be potential clients of the distribution company since the distribution company could not offer any significant cost saving. Further, companies with very small operations, such as a small foundry with fifty or so employees, will probably not use the distribution company because they will tend to manufacture to specific order rather than manufactuer to inventory. Therefore, the potential clients are those who manufacture or process goods for inventory (that is, manufacture or process goods without having a specific sales order for the goods) and have small-scale operations at one or both ends of the distribution chain.

Distribution Company Services

The services provided by the distribution company can be divided into two broad categories, physical and management services. The physical services pertain to the actual handling of commodities, whereas the management services pertain to the information flow necessary to the operation of the distribution network.

Physical services

The physical services that are generally provided by the distribution company are:

Transportation to the distribution center
Receipt
Warehousing
Order picking
Manufacturing, assembly and break-bulk operations
Packaging, marking and tagging
Processing display material
Shipping
Transportation from the distribution center

The services are listed above in the sequence that will apply for a typical shipment moving through the distribution center. The principal services that cannot be avoided are receipt, warehousing, order picking and shipping. The other services listed above are optional and would be provided by the distribution company if requested by the customer.

The receipt service is the actual acceptance of the cargo and includes counting, inspection, moving to storage location in the warehouse, etc. Warehousing is holding and protecting the cargo until needed. Order picking is the process of selecting goods from the warehouse area for further processing or shipping. Order-picking operations vary considerably in scale. Goods from a large grocery manufacturer will generally arrive in full pallet loads and a large portion of the shipments from the center will be full pallets. A smaller manufacturer may send goods to the center in full pallet loads, but shipments from the center are probably part pallet loads, cartons or in consolidated pallets containing items from many manufacturers. The shipping service includes the final inspection, counting and delivery of the goods to the customer's agent. The distribution company staff may or may not perform the actual unloading (receiving) and loading (shipping) of the transport equipment depending on vehicle ownership, union rules and client wishes. The distribution company provides economies to the customer when providing the four basic physical services inasmuch as the staff and the facility are used jointly by many customers.

The transportation services provided by the distribution company (transportation to and from the distribution center) implies that the company has direct control over the vehicles. Clients, of course, could use their own equipment if they so desired. A third transportation option, forwarding, is discussed below under Management Services. The distribution company could realize transportation economies, particularly in load pickup and delivery, through the pooling of vehicles and more efficient vehicle routing.

The distribution company can provide a range of services other than those directly associated with the conventional concept of a distribution network. We have included three broad categories of these extra services in the above list. Manufacturing, assembly and break-bulk operation usually entail some sort of commodity form change, whereas packaging, marking and tagging do not. The distribution company could perform a manufacturing or assembly function for a client. However, this activity is usually limited because the manufacturing and assembly machinery and labor skills cannot be used for a wide variety of customers and because Montreal's labor costs are high. Therefore, if a client is to realize an overall saving, it must come from a saving in duty, in insurance and breakage and in transportation costs or because the components came from diverse sources. Components could move more cheaply than the finished products because of commodity rates, high density, reasons of safety or reasons of risk (insurance). We cannot envision assembly of watches or complex electronic equipment as a distribution center function, but sporting goods, electrical appliances, plastic products, hardware products and bookbinding could possibly be partially manufactured or assembled in the distribution center.

We have included break-bulk operations in the same category as manufacturing and assembly as it usually is the conversion of a bulk product to consumer or user packages. Thus, it is closely related to repackaging. The advantage to the client includes reduced transportation and storage costs. Once again, these savings must offset Montreal's high labor costs.

Clients requesting manufacturing, assembly and break-bulk operation services of the distribution center may also realize a saving in taxes and duty, particularly if the distribution center is exempt from local taxes on goods processed for consumption elsewhere. Reno, Nevada serves this function for the California market. Montreal may perform a similar role for the northern Ohio, Pennsylvania, upper New York and upper New England markets.

Packaging, tagging and marking services can also be provided by the distribution company. These services are of particular value for clothing, shoes, "gifts" and leather goods and are an important function for imported goods. Gilbert Flexi-Van Corp., a U.S. forwarder, performs these services for clients in the fashion garment industry. These clients include chains (for example, Penney's, Macy's) and other consignees as well as manufacturers. Shoe imports are another commodity that can use the packaging, tagging and marking services of the distribution center. The tasks performed by the center could include putting shoes into boxes and price marking for consignees. These functions can, of course, be combined with order picking. The packaging, tagging and marking services will probably be more widely used in a distribution center located in Montreal than one located elsewhere because of the need to have French or bilingual labels.

The preparation of display material and its distribution is closely related to repackaging. This service is of particular importance to industries with frequent and rapidly changing promotional programs (for example, cosmetics, records and tapes). Montreal can serve effectively as the North American center for distribution of display material from overseas suppliers.

The extra services of manufacturing, packaging and display materials should only be provided if the distribution company can enlist a number of clients requiring the same machinery and labor skills. Multiple clients are required in order to realize the economies of scale necessary for the distribution company to operate efficiently. Therefore, an investigation of specific industries and companies will be required before these services are offered, especially if specialized equipment and skills are to be used.

We indicated above that the sequence shown in the list of peripheral services would be the general sequence of events as goods passed through the distribution center. Obviously, the sequence can be altered to fit circumstances. For example, parts could be "order picked" from the warehouse area, assembled, and returned to the warehouse area to await receipt of shipping orders. Specific clients, of course, may request this sequence in order to minimize the time between receipt of an order and shipment of the goods. We believe that most clients requesting services requiring manufacturing, assembly or break-bulk operations will prefer the sequence listed above in order to minimize their "investment" held in the distribution center. Clients requesting packaging, marking and tagging or display material services most likely will not know the specific packages, marks, etc. that will be required until receipt of an order. These clients, then, will also generally prefer the physical service sequence listed above.

Management services

The basic management services a distribution company should provide are:

- Documentation
- Inquiry, order transmittal
- Billing, invoicing
- Inventory control, restocking
- Forwarding

Documentation is the normal record-keeping activity associated with the operation of a distribution center and includes keeping shippers and consignees informed on the status of their goods in the center (shipments made or received, shipping schedules, etc.). As such, it is the only mandatory management service; the other services are optional and may be requested by individual clients.

Order transmittal and inquiry services are related as they define the distribution company's responsibility as far as acting as the shipper's agent. The distribution center could respond to a consignee's request by shipping goods without specific and prior approval by the shipper (order transmittal service). The shipper is notified of the shipment after the fact either immediately or periodically as he requires. The distribution company could also assume the responsibility for responding to an inquiry as to the availability of certain goods (inquiry service). A subsequent order may be placed with either the distribution company or the shipper but, in any event, the distribution company must obtain specific approval from the shipper before completing the order. A shipper may request the order transmittal service for a selected group of preferred customers and inquiry service for all others. Shippers who do not request either the inquiry or order transmittal service must deal directly with their customers.

The distribution company could provide a billing and invoicing service. If the shipper bills locally rather than centrally, the distribution company can bill directly as the order is shipped and thus reduce delays in billing. Shippers who bill from a central location must wait notification from the distribution company that the goods were shipped. This notification would be part of the normal documentation service.

The inventory control and restocking services are related in that the purpose of both is to maintain adequate inventory levels at the distribution center. In providing the inventory service, the distribution company assumes the responsibility for informing the shipper when his inventory has reached the reorder point. This service is valuable when the shipper has requested the distribution company to provide the order transmittal service. Otherwise, this service would be redundant because no shipments are made without the specific approval of the shipper and he should be aware of his inventory level. The distribution company could provide a restocking service and assume the responsibility of replenishing stocks when the inventory falls below a predetermined level. This service would be attractive to a group of customers who are drawing supplies from a common inventory.

The distribution company may provide a forwarding service in the sense that the company arranges for transportation on vehicles not controlled by the distribution company or the client. This service would generally be provided where the consignee is located in an area not served by vehicles controlled by the distribution company.

The distribution company must have a clear definition of the ground rules in order to provide the optional management services. Each client may require a different set or group of physical and management services. Therefore, large amounts of information must be stored and rapid retrieval of selected items of information is essential, particularly if the distribution company provides inquiry, order transmittal, inventory or restocking services. These information requirements suggest the use of a computer with remote terminals located throughout the center in functional areas requiring rapid access to information.

It has been suggested that a distribution center could attract a sufficient amount of containerized cargo to make container management, leasing and even perhaps loading and unloading (stevedoring) containers an attractive service for the distribution company. We have shown later in this report (see page 211) that the distribution center could attract at most 8,100 tons of containerizable cargo annually. This movement is roughly equivalent to 800 containers per year or between 2 and 3 containers per day. We do not believe a movement of this order of magnitude would make such container services a viable enterprise.

Market Potential

The market for a distribution center is in every sense a subset of the total demand in the region to be served. The region itself can only be loosely defined because regional marketing boundaries for distribution by a company depend on the products, marketing and distribution channels used, costs and competitive factors. In this case we must also consider the presence of international boundaries.

In our study we have broken this section on markets into five subsections:

1) Geographical considerations
2) Commodity considerations

3) Market size

4) Market for auxiliary physical services

5) Market for auxiliary management services

The first three subsections estimate the total market potential of a distribution center. The remaining subsections estimate the portion of the total market that will use the auxiliary services. Distribution center and transportation costs which play a role in attracting and holding distribution center customers are treated in the next section.

We note here that distribution centers, in the last analysis, serve their customers who distribute commodities in the region. It is customers who must be attracted and served. Commodity characteristics are an indication of the customers to be sought -- the ultimate commodity and customer mix will define in detail the size and services offered by the distribution center. We can only estimate the size and services in terms of an approximation of commodity and customer mix. In our cost analysis, for example, we have assumed that the major distribution of grocery products will not use the distribution center because they can achieve economies of scale within their own operations. The first targets for a distribution center serving the U.S. and Canada should include the following industries:

1) Shoes, clothing and accessories

2) Household equipment and appliances

3) Motor vehicle and engine parts

4) Electrical and nonelectrical equipment and parts

Geographical considerations

The population and industrial centers in Canada are much more concentrated than in the United States. More than 60 per cent of Canada's population and about 80 per cent of Canada's manufacturing activity occurs in a narrow corridor between Windsor, Ontario and Quebec City. The corridor includes two major North American industrial and commercial centers, Toronto and Montreal. Table 33 lists the population and value added in manufacturing in 1969 for the major Canadian centers. The table is organized so that the 19 centers include the total Canadian population and value added -- rural areas and smaller CMA's have been assigned to the nearest major center. Charlottetown, P.E.I. has been included so that all provinces are represented. Table 34 shows the data on economic indicators by region.

If we incorporate a key portion of the U.S. market into the picture (for example, upper New York State, upper New England and the eastern Great Lakes region), some complications arise. It is clear that Montreal is in one corner of the enlarged market zone and, while Toronto is more centrally placed, there are even larger centers of population and activity which compete with the Canadian centers -- Cleveland, Pittsburgh and Detroit. Within this extended region the natural market for a Montreal distribution center includes:

1) Montreal, Quebec, Ottawa
2) Syracuse, Albany, and about one-fourth of Boston and Portland
3) All of eastern Canada

Table 33

POPULATION DISTRIBUTION AND VALUE ADDED IN INDUSTRY CANADA 1969

CMA	Fraction of Population		Fraction of Value Added	
St. John's	0.0245		0.0050	
Charlottetown	0.0052		0.0009	
Halifax	0.0363		0.0140	
Saint John	0.0297		0.0122	
Atlantic Provinces		0.0957		0.0321
Montreal	0.2437		0.2614	
Quebec	0.0411		0.0212	
Quebec		0.2848		0.2826
Hamilton	0.0427		0.0861	
Kitchener	0.0183		0.0362	
London	0.0200		0.0249	
Ottawa	0.0470		0.0178	
Toronto	0.2067		0.3037	
Windsor	0.0199		0.0570	
Ontario		0.3546		0.5257
Winnipeg	0.0466		0.0247	
Regina	0.0238		0.0048	
Saskatoon	0.0219		0.0049	
Calgary	0.0343		0.0142	
Edmonton	0.0400		0.0193	
Prairies		0.1666		0.0679
Vancouver	0.0829		0.0847	
Victoria	0.0154		0.0070	
British Columbia		0.0983		0.0917
TOTAL	21.06×10^6		$\$14.74 \times 10^9$	

Source: Canada Year Book 1970-71.

Table 34

DISTRIBUTION OF ECONOMIC ACTIVITY BY REGIONS
CANADA 1969

Region	Share of Population	Share of Retail Sales	Share of Wages & Salaries	Share of Value Added
Atlantic Provinces	0.096	0.08	0.06	0.032
Quebec	0.285	0.26	0.28	0.283
Ontario	0.354	0.38	0.42	0.525
Prairie Provinces	0.167	0.17	0.14	0.068
British Columbia	0.098	0.11	0.10	0.092

Source: Canadian Statistical Review, April 1972, Information Canada, Ottawa.

The population and value added for these market areas are given below for 1969 in terms of the fraction of Canadian population and value added in manufacturing (U.S. population taken as ten times Canada's and U.S. value added in manufacturing as twenty times Canada's, close to 1970 values).

		Population	Value Added
	Montreal	0.244	0.261
	Quebec	0.041	0.021
	Ottawa	0.047	0.018
1)	Montreal and region	0.332	0.300
	Syracuse	0.054	0.136
	Albany	0.072	0.134
	One-fourth Boston and Portland	0.094	0.207
2)	Northeastern U.S.	0.220	0.477
3)	Eastern Canada	0.096	0.032
	TOTAL	0.648	0.809

For the distribution of North Atlantic imports (to U.S. and Canada) this basic market area can be enlarged, particularly for high-valued goods. For distribution of U.S.-produced products the market area will be smaller, with the U.S. portion probably supplied from U.S. distribution centers. For goods produced in Quebec Province for doemstic and transborder sales, the market area will be enlarged; for goods produced in Ontario, the market area will be reduced.

The total market area given above is two-thirds of Canada's by population and eight-tenths by value added (in 1969 Canada's population was estimated at 21,300,000 and its value added in manufacturing as $14,750,000,000). Thus we consider a market area of about 14,000,000 people and a value added in manufacturing of about $12,000,000,000.

The market area for an individual product or a company will vary depending on channels of distribution, product line relationships (for example, produced in proximity or apart, connected sales), method of distribution, value/weight ratio and the special requirements for storage.

Using the basic data on population and value added, we have computed a measure of distribution cost from both Montreal and Toronto. We assume that distribution cost is strongly dependent on transportation cost and that transportation cost is only a function of distance. We further assume that demands are proportional to one of the factors: population, value added in manufacturing, wages and salaries, or retail sales. The results in units of "factor-miles"* are shown in Table 35.

In all cases the cost measure of factor-miles is lower for distribution from Toronto than from Montreal. However, with the exception of value added, the differences between Toronto and Montreal are small, of the order of 0.8 to 1.5 per cent. One can only make broad general

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*Factor-miles are the product of the portion of the factor at the CMA and the distance from a center to the CMA. Factor-miles are summed over all CMA's to obtain comparative figures.

Table 35

COMPARISON OF DISTRIBUTION CENTERS AT MONTREAL AND TORONTO
(Canadian Market Only)

Region	Distance x Population		Distance x Retail Sales		Distance x Wages		Distance x Value Added	
	Montreal	Toronto	Montreal	Toronto	Montreal	Toronto	Montreal	Toronto
Atlantic	60.7	93.4	51.0	78.0	37.8	58.0	17.4	27.9
Quebec	6.2	106.5	5.7	97.5	6.1	104.0	3.2	102.7
Ottawa	5.9	11.9	6.3	12.6	7.0	14.2	2.2	4.5
Ontario (less Ottawa)	117.2	8.9	125.0	30.6	139.0	34.2	198.4	19.5
Prairies	323.5	300.3	330.0	307.0	273.0	254.0	130.8	121.2
British Columbia	312.3	298.7	315.0	302.0	288.0	274.0	290.8	278.2
TOTAL	825.8	819.7	833.0	827.7	750.9	738.4	642.6	554.0

conclusions from this simple analysis; the situation for specific companies, product groups, and industries differs and deserves individual attention.

1) A machinery and industrial products distribution center probably should locate in Toronto or Ontario because of the preponderance of manufacturing activity in Ontario.

2) Consumer product distribution centers can be efficient from either Toronto or Montreal, or even in between because of the concentration of population in the Windsor-Quebec corridor.

3) Companies located between Montreal and Toronto and having a single distribution center can distribute efficiently from their plant location, because the cost of extra handling cannot be overcome by a more efficient location.

The simple analysis above is indicative rather than precise, and it deals with the location of a single distribution center rather than with multiple distribution centers. The assumption of transportation costs as a linear function of distance is only a rough first approximation -- for example, it assumes no fixed costs associated with cargo movement or distribution center operation. In addition, it assumes no cost for moving inventories into the distribution center from manufacturing locations.

In Table 36 we show the system costs for two distribution centers, one in Montreal and one in Toronto, for the factors population and value added. In these cases, the total cost of transportation

Table 36

MINIMUM COST DISTRIBUTION CENTER ASSIGNMENTS
(Canadian Market Only)

	Distance x Population		Distance x Value Added	
CMA	Montreal	Toronto	Montreal	Toronto
St. John's	24.5		5.0	
Charlottetown	2.6		0.5	
Halifax	16.3		6.3	
Saint John	17.3		7.1	
Montreal	0		0	
Quebec	6.2		3.2	
Ottawa	5.9		2.2	
Hamilton		1.7		3.4
Kitchener		0.9		1.8
London		2.3		2.9
Toronto		0		0
Windsor		4.0		11.4
Winnipeg		61.0		32.3
Regina		39.8		7.9
Saskatoon		39.8		8.9
Calgary		73.6		30.5
Edmonton		86.3		41.6
Vancouver		251.0		256.5
Victoria		47.7		21.7
TOTAL	72.8	608.1	24.3	418.9
GRAND TOTAL	680.9		443.2	

is reduced by more than 100 units, but it is not clear that two centers are more efficient than one because one must add back the fixed costs of operating a second center.

Given the present distribution of population and economic activity and the trends of the last decade, Montreal's advantages as a distribution center stem from:

1) The population of the Montreal CMA itself.

2) Montreal's port facilities and port activity.

3) Access to a portion of the U.S. market which can be served efficiently from Montreal.

Toronto can also serve Buffalo and Rochester in the U.S., but Toronto itself is dominated by Cleveland, Pittsburgh and Detroit in the United States. Time is an important factor in the development of a distribution center. Montreal can have a three- to five-year lead, and with such a lead it can maintain its market share.

Commodity considerations

There is no complete data base for domestic shipments in either the United States or Canada. At three-year intervals the U.S. Bureau of the Census conducts a census of transportation; the last year for which data are available is 1967. The Census of Transportation is not a complete data base; for example, the point-to-point movements of specific commodities are not provided, nor is there a shipment size distribution for movements between two specified regions or an extension to nonmanufacturing industries. It does give movements of broad commodity classes from region to region (including shipment size) and the size and the distance distribution for a commodity class by mode independent of regions of origin and destination.

Data for Canada are less complete. Data on shipment value by broad industrial classification are available, as are railroad carloadings by the same classification. Thus, it is difficult to obtain measures of domestic movement. A gravity model has been suggested as a means of obtaining transportation and distribution data for Canadian movements, but the required sample of transport waybills to obtain coefficients is not yet available. We estimate that a sample study would cost well in excess of $150,000.

The average monthly domestic manufacturing shipments in Canada in 1970 totaled $\$3.83 \times 10^9$, of which $\$2.06 \times 10^9$ were in durable goods and $\$1.77 \times 10^9$ in nondurables.* The candidate classifications for a distribution center and the average monthly shipment values in 1970 are shown in Table 37. We omit chemicals, wood, petroleum products, textiles, and knitting mills, metals and metal fabricating, nonmetallic minerals and paper and printing, etc. because these products tend to be shipped in bulk and have too low a value.

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*Canadian Statistical Review, April 1972, Information Canada, Ottawa.

Table 37

AVERAGE MONTHLY MANUFACTURING SHIPMENTS, CANADA 1970
(Millions of Dollars)

Industrial Classification	Total Amount	Maximum Candidate Percentage	Maximum Estimated Amount
Rubber	52.5	0.30	15.8
Leather	33.8	0.60	20.3
Clothing	110.6	0.60	66.3
Furniture and fixtures	60.2	0.50	30.1
Machinery	149.6	0.25	37.4
Electrical products	220.0	0.50	110.0
Miscellaneous manufactures	114.9	0.50	57.5
Transportation equipment	472.4	0.10	47.2
Foods	718.3	0.05	35.9
TOTAL	1,932.3		460.5

Source: Canadian Statistical Review, April 1972.

National manufacturing shipments have an average value of $460,500,000 per month. On a population basis, Montreal and its market region would account for about 33 per cent of this total; on a value-added basis, it would account for about 30 per cent of the total. These figures would have to be reduced to reflect local deliveries and movements for large manufacturers and distributors who will maintain their own warehouses, for the many movements from manufacturer direct to retailer, and for production to order, particularly in the machinery and electrical products section.

From an analysis of the U.S. Census of Transportation we have created a list (Table 38) of candidate commodities and products for a distribution center. Our logic in selecting these products is based on:

1) A large portion of production not being for local consumption.
2) Shipments tending to be smaller than 30,000 pounds.
3) Value per pound tending to be in the medium to high range.

The list in Table 38 is not meant to be complete -- generally commodities are given in three- or four-digit Transportation Commodity Classification (TCC) used in the U.S. Census of Transportation. We should also note the limitations of the census itself. It is based on a small sample of about 100 to 200 bills of lading at each of about 13,000 plants. The sample does not include shipments from warehouse to user (except from plant warehouses), nor does it correctly assign multiple commodities on a single bill of lading.

Table 38

TONNAGES OF CANDIDATE COMMODITIES
(Thousands of Tons)

	Commodity	
207	Confectionary and related products	4,292
231	Men's, boys' and youths'	965
233	Women's, misses' and infants'	993
238	Raincoats and waterproof garments	20
239	Miscellaneous fabric and textile products	1,862
251	Household and office furniture	4,604
283	Drugs	1,664
2844	Perfumes, cosmetics	1,359
302	Rubber footwear	312
306	Miscellaneous rubber fabric products	2,207
307	Plastic products	4,297
314	Footwear, leather	404
316	Luggage and handbags, leather	205
3262	China and earthenware table and kitchenware	245
342	Cutlery, handtools and general hardware	1,616
3432	Plumbing fittings	343
34336	Heating equipment parts	42
34612	Hospital and kitchen utensils	208
3545	Machine tool accessories, tools and measuring devices	78
357	Office, computing and accounting machines	463
3611	Measuring instruments, etc.	108
3613	Switchgear	337
3622	Industrial controls and parts	188
3634	Electrical housewares and fans	246
3636	Sewing machines and parts	22
364	Electrical lighting and wiring equipment	2,215
365	TV, radio, phongraphs and records	1,110

Source: U.S. Census of Transportation, 1967.

Table 38, continued

	Commodity	
367	Electrical components and accessories	631
369	Miscellaneous electrical equipment and supplies	1,803
3722	Aircraft engines and parts	229
3729	Aircraft parts and equipment	376
375	Motorcycles, bicycles and parts	196
38	Instruments, photographic, optical, watches	1,034
39	Miscellaneous manufactures	2,445
	TOTAL	37,119

The U.S. sample data are in finer detail than that for Canada, and they are given in tons rather than in dollar value. If we assume that the total tonnages of the listed commodities are candidates, then for the United States we have 37,200,000 tons. Now assuming that Canada's population is one-tenth that of the United States, we have an estimate of 3,720,000 tons for Canada. For Canada we have monthly manufacturing shipments of \$460,500,000 (from Table 37), or an annual value of \$5.52 x 10^9. Thus we have an estimated value of goods of \$1,480 per ton or \$0.74 per pound. This is a reasonable value for consumer and industrial goods which will move via a general distribution center.

Market size

As mentioned previously, the share of the Montreal market area (including Quebec and Ottawa) would be about one-third of Canada's total. However, a much smaller portion of Canada's domestic trade would move through a Montreal distribution center. Goods produced for local consumption, the goods for the larger supermarket and department store chains, much of the machinery and electrical goods produced in Ontario and, in fact, some share of every commodity class, will move through company-owned or distributor-owned warehouses. At most about 15 per cent of Montreal's market share (or about 5 per cent of Canada's total domestic distribution of the candidate commodities) would move via the distribution center. This amounts to about 185,000 tons per year or about 10,000 truckloads per year of loadings and the same number of unloadings (about 10,000 truckloads in and 10,000 truckloads out per year) and perhaps 13,000 truckloads per year in 1975.

Thus far we have omitted the distribution of imports by the distribution center. Import commodities are prime targets for the distribution center. Montreal's position as a major ocean port and a major international air center provide an opportunity for North American distribution of important import commodities, and at least for regional distribution in Montreal's natural market area in the United States and Canada.

Total 1975 North Atlantic imports, in tons, including air cargo and existing surface cargo with an average commodity value of $1.00 per pound or more is expected to be as follows:*

Montreal	24,000		
Quebec	4,000		
Ottawa	4,700		
Canada prime area		32,700	
Syracuse	4,300		
Albany	6,000		
1/3 Boston	8,270		
U.S. area		18,570	
St. John's	2,500		
Charlottetown	500		
Halifax	3,300		
Saint John	2,700		
Eastern Canada		8,900	
TOTAL			60,170

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*See Tables C-6 and C-14, Appendix C.

More than half of this cargo will move by air, and of the air portion about half will be emergency shipments not candidates for a distribution center. On the other hand some lower-value goods may be candidates for the air emergency shipments. Of the total 60,000 tons, perhaps 15 per cent (9,000 tons) will move through the distribution center.

The expected tonnage of Canadian exports to the U.S. valued at $1.00/pound or more moving from Montreal to our prime U.S. area is 2,300 tons (the prime area will import only 13,200 tons of such commodities from all of Canada).* Some of these same commodities will move in Canadian domestic trade through the distribution center; but they can only contribute about 2,000 tons of transborder trade to distribution center throughput.

The U.S. trade to the prime area and Eastern Canada, including air cargo and commodities with an average of $1.00 per pound or more will be about 375,000 tons in 1975; only about 20,000 tons of this trade originates in the Syracuse, Albany and Boston regions. The breakdown of the forecast movements to the Canadian market area, in tons, is as follows:

Montreal	214,000		
Quebec	36,000		
Ottawa	41,000		
Canada prime area		291,000	
St. John's	22,000		
Charlottetown	5,000		
Halifax	32,000		
Saint John	26,000		
Eastern Canada		85,000	
TOTAL			376,000

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*Table C-18, Appendix C.

Only a portion of the commodities in this trade are candidates. They can be considered as the same groups as for Canadian domestic trade. In the domestic trade, about one-eigth of the dollar value of manufactures were candidates for the center. The U.S.-Canada volume above includes items other than manufactures, but it does not include commodities with values less than $1.00 per pound. Assuming these balance, we would then obtain a figure of something less than 50,000 tons a year. If we take 20 per cent of this figure (a higher percentage than was used for domestic movements) we have an estimate of 10,000 tons per year.

Thus our estimate of maximum throughput in 1975 for a Montreal distribution center consists of the following:

	Tons
Domestic Canada	250,000
Foreign imports*	9,000
Canada to U.S.	2,000
U.S. to Canada	10,000
TOTAL	271,000

Auxiliary physical services

The additional physical distribution services are not applicable to all customers and all commodities. Even consolidating for consignees implies that more than one customer of the distribution company supplies the same consignee -- this may not be true for all potential consignees. Another form of consolidation for consignees is even more restricted -- that is, acting as agent for the consignee by collecting and receiving goods from suppliers who do not use the distribution center.

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*Excluding shipments from the United States.

Marking and tagging and preparation for sale are appropriate activities for footwear, leather goods, clothing and apparel, hardware and cutlery and some miscellaneous manufactures. These commodities amount to about 10 per cent of the total tonnage (but more than 10 per cent of the total value) of candidate commodities. Only a portion of the throughput of these commodities will require such additional services; but an average daily tagging and marking throughput of only two to three tons can provide significant revenue to the distribution center. We estimate the demand at the distribution center at about 2,000 to 3,000 tons per year. The tagging and marking area should be close to the outbound palletizing and packaging stations. The exact equipment and layout specifications will depend on the customer and commodity mix.

Packaging services are also dependent on the customer and commodity mix at the distribution center. While the range of packaging services can be quite broad (say from bottling vegetable oil to packing tights in egg-shaped containers), the needs for distribution center customers will be more restrictive. Packing lines must have enough volume to merit some mechanization to keep costs within bounds. Candidates for packing services include footwear, clothing and apparel, drugs, cosmetics, plastic products, parts (electrical and nonelectrical), and cutlery and hardware. While these represent a much larger share of the total of candidate commodities, a much smaller portion will make use of the services. The commodities which can use packaging services amount to more than 30 per cent of the total of candidate commodities, but, since many products have strong brand names and many must be packaged at the production facility, we estimate the maximum demand at only 3 to 3.5 per cent or only 8,000 to 10,000 tons a year.

Bulk operations can be compared with packaging; the source material in the former case is a bulk shipment (say a tank car of vegetable oil, or a carload of rice) rather than a pallet of unpackaged items or parts. We do not envisage bulk operations in the initial operation of the distribution center although drugs and cosmetics for minor brands are good candidates. These products require special sterile facilities and careful quality control. Certain grocery products such as vegetable oils, rice and other whole grains, and beans and lentils, are potential users of bulk packaging services but we do not expect grocery products to be a major commodity in this installation.

Manufacturing and assembly depends most strongly on the customer mix. Because of the need for mechanization, these services can only be taken on by a new distribution center under contractual agreement with specific companies. The high wage rates in Montreal do not encourage assembly; however, if significant savings in transportation and breakage are possible, then assembly operations at the distribution center may be economically feasible. We cannot anticipate volumes or products at this time, but we do not believe this will be an important service at the distribution center.

Auxiliary management services

The management services offered by a distribution center are applicable to most of the commodities and companies using the center. The extent to which they will be used depends on the type of customer mix attracted to the center. Companies using centralized billing and invoicing systems will tend to maintain their own system rather than assign such services to an independent distribution center. These same companies may, however, pass on inquiry and order transmittal functions to the distribution center.

National Distribution Corp. (NDC), which has spent in excess of $1,000,000 in studies and planning for a distribution center network, has stated that the typical candidate company or division of a company has annual sales in the range from $20,000,000 to $50,000,000, distributes nationally or over an extensive region and has products of medium to high value per pound. Such candidate companies have management and central systems of from a below average to a well above average degree of sophistication. NDC plans to install a large computer and a computer network for management and control of between-center transportation, internal operations and customer services. Here we are concerned with a single center, some of whose customers will be smaller than NDC's typical customer and, except for inventory control and restocking, having little to do with inbound transportation. We see a reasonably large demand for management services but a requirement for only a medium-sized data processing system to handle internal operations and management services for the customers of the center.

The documentation, which is the normal record-keeping activity of warehouses or distribution centers, will apply to all commodities and all customers. Export and import documentation services apply only to goods received from abroad (foreign and transborder) and transborder shipments. These are only a small portion of the total (21,000 tons out of 271,000 tons).

The inquiry service is applicable to all companies, but highly centralized organizations may prefer to retain full control, not only of their products in warehouses, but also of information on availability. Similarly, orders can be accepted and filled by the distribution center (from an approved customer list), for almost all client companies, with the client company informed after the fact. The extent to which this will be permitted depends on the organization and methods of the client company. The broad applicability of the services described above also extends to billing and invoicing and to inventory control and restocking.

If we consider a distribution center with a throughput of 150,000 tons a year (750 tons/peak day) serving 20 clients, each with, say, 1,000 line items and 50 local customers, the information storage required is large and activity is at moderate levels for data processing. As a rough indicator we will have about:

20 x 1,000 client SKU* records

20 x 50 customer records

300-400 customer shipments/day (@ 4,000 pounds/shipment)

4,500-6,000 SKU shipments out/day (@ 15 SKU's/shipment)

50 shipments in/day (@ 15 tons)

500 SKU shipments in/day (@ 10 SKU's/shipment)

There is no question of the scale of activity creating problems of data processing or organization even when clients use all services. The problem is one of scaling the data processing and office functions to meet the demand for services at an economic price, a danger of over-specifying equipment and staff rather than not being able to meet demands.

The demands, as we have emphasized earlier, are a function of the customer-commodity mix that will be attracted to the distribution center. No one can list specific companies, company groups or divisions of companies without an extensive study of business organizations operating in the extended market area. We cannot estimate the market for all services but we feel that the weighted demand for services will be equivalent to between 30 to 50 per cent of the throughput requiring all services. Given the state of the art of data processing design, growth can be accommodated by selecting a central processor of moderate speed and adding increments of memory storage and terminals to meet growth requirements.

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*Stock keeping unit.

Distribution Center Costs

Distribution center activity falls into three broad categories:

1) Warehouse functions
2) Drayage and transportation
3) Auxiliary physical and information services

While individual contracts may cover a specific "service package" it is anticipated that each service will be self-supporting.

The detailed cost for a service package for a customer depends not only on the services but also on the commodity and the nature of the business activity of the company for whom the service package is prepared. This has been recognized in the public warehouse business where service bids are generally based on engineered standards conforming to commodity characteristics, order size (both incoming and outgoing) throughput and turnover. Given the broad range of commodity characteristics, company distribution patterns and service options, one cannot establish a single set of costs applicable to all commodities and all customers. Hence, the following discussion on costs should be considered as general guidelines rather than precise cost estimates.

Warehouse functions

The basic warehouse cost structure for a given commodity or commodity group is a function of throughput and turnover (if we exclude drayage costs which depend, in addition, on order size and order frequency). Throughput is the tonnage or volume into and out of the warehouse in a unit of time, for example, cases per month or tons per year. Turnover is the ratio of throughput to average inventory in the warehouse, or for highly seasonal goods, the ratio of throughput to maximum inventory. A specific commodity or a commodity group is characterized by the warehouse area and cubic footage required to store a unit of the commodity in the warehouse, and by the handling man-hours required to unload, store, order pick and load a unit of the commodity.

The elements of the cost structure of a warehouse are shown in Table 39. We have indicated the assignment of the cost element to either handling or storage following procedures used by the public warehouse industry. The general and administrative costs might more properly be assigned to both the storage and handling functions. The cost elements also exist in company-owned and -operated warehouses, and we shall examine the effects of scale and joint operation on major cost elements.

For a given throughput D, space requirements are a function of turnover T

$$S = A\frac{D}{T} \tag{1}$$

Table 39

COST STRUCTURE

	Storage	Handling
HANDLING		
Office and supervision	x	
Operating labor		x
Contract labor		x
Payroll costs - preparation		x
Highlift (forklift)		x
Maintenance and fuel		x
Freight and drayage		x
SPACE		
Rent	x	
Sprinkler	x	
Property taxes	x	
Depreciation and amortization - autos, forklifts, racks	x	
Maintenance	x	
Insurance	x	
Warehouse cleaning	x	
Claims	x	
Utilities	x	
Protection - ADT	x	
Equipment rentals		x
Miscellaneous materials	x	
Janitorial	x	
Pest control	x	
Others	x	
GENERAL & ADMINISTRATIVE		
Salary distribution - management	x	
Travel and entertainment	x	
Telephone	x	
Telegraph	x	
Postage	x	
Office supplies	x	
Office rentals	x	

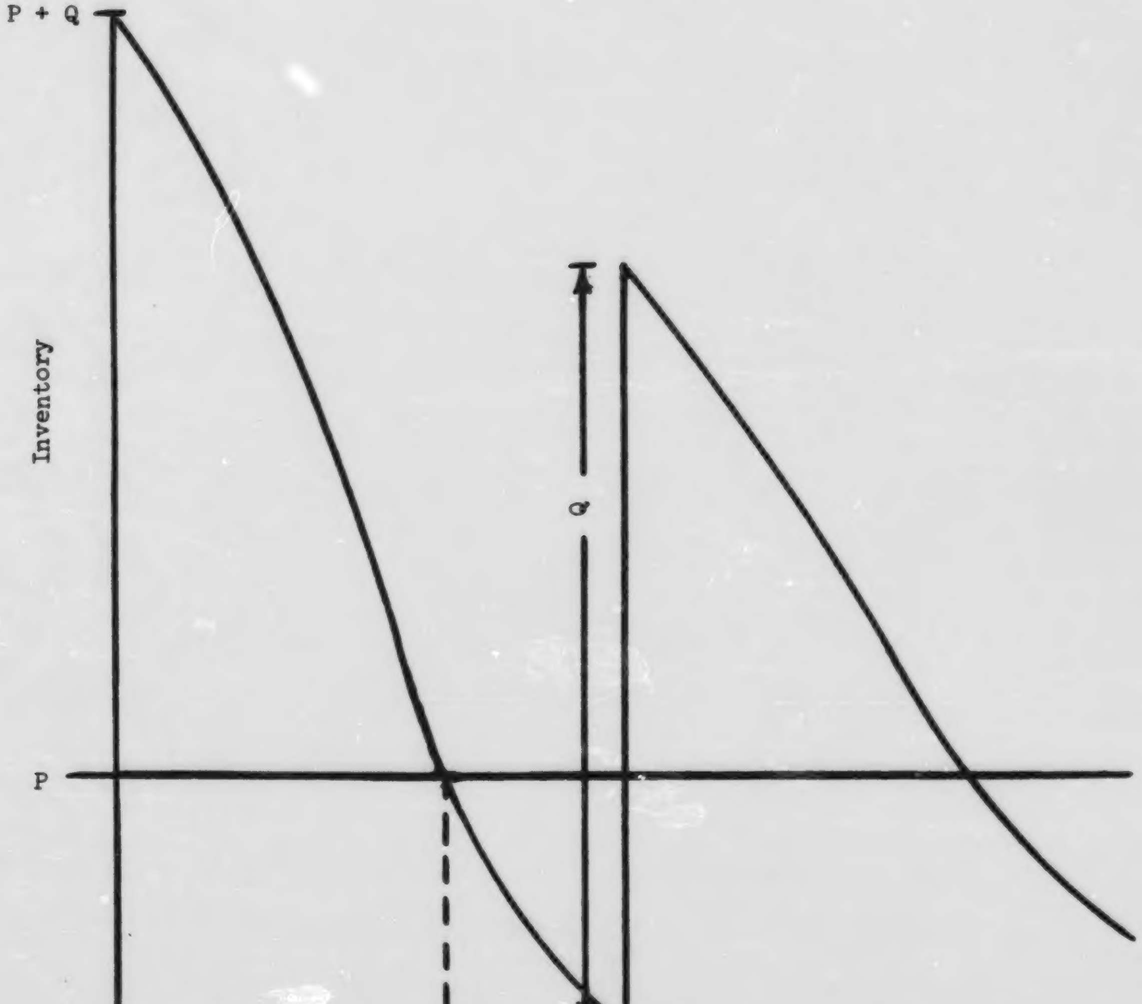
where S is the space required and A is the space requirement per unit of the commodity, taking into account allowable stacking and aisle space. Turnover rates show a wide variation depending on commodity, commodity mix, the type of business and distribution procedures. For chain groceries we find a range of $13 \leq T \leq 29$ (this includes meat and produce as well as grocery items). For independent department stores, each concentrated in only one city, we have a range of $4 \leq T \leq 8.5$. These figures are for total inventory including both retail outlets and warehouse and are computed as the ratio of inventory value to total sales. Correcting for the difference between purchase price and sales price and for the inventory at retail outlets, the actual ratio would be higher.

We would expect hardware and spare parts wholesalers or manufacturers to have turnover ratios of three or four and produce distributors to have ratios greater than forty. For the eligible commodities and companies we will be mainly concerned with turnover ratios in the range $3 \leq T \leq 25$. Turnover ratios using distribution centers are higher than those using multiple warehouse locations.

From basic inventory theory we know that turnover is a function of annual sales. Let us consider the lot size policy of inventory management. In this policy one orders a fixed quantity Q when the supply on hand falls to a reorder point P. The reorder point is selected to cover the expected demand in the lead time L plus a safety stock to cover variations in demand and in lead time. Figure 25 shows the behavior of the inventory level as a function of time.

Figure 25

INVENTORY REPLENISHMENT



In this system the total variable cost (TVC) can be written as

$$TVC = \frac{CD}{Q} + \frac{Q}{2}h + K\sigma h \qquad (2)$$

where C is the cost per order placed, D is the annual demand, h is the cost of holding a unit in inventory per year, σ is the variation of demand in the lead time and k is a safety factor for variations in demand (k = 2 for 95 per cent protection against shortages).

The optimal lot size Q* (to minimize inventory cost) is

$$Q = \sqrt{\frac{2DC}{h}} \qquad (3)$$

and the average inventory is $\frac{Q}{2} + k\sigma$. Ignoring $k\sigma h$ for the moment, the turnover T is

$$T = \frac{D}{\text{average inventory}} = \frac{2D}{Q}$$

$$T = \sqrt{\frac{2Dh}{C}} = D^{\frac{1}{2}}\left(\frac{2h}{C}\right)^{\frac{1}{2}} \qquad (4)$$

so that turnover increases as the square root of the annual demand (D). Figure 26 shows turnover as a function of throughput. Now, if the demand per period (t) has a Poisson distribution, the variation of demand equals the square root of demand per period (that is, $\sigma = \sqrt{D/t}$) and the effect is to keep the relationship in Figure 26, but to lower the throughput curve to reflect the presence of safety stock. We can express this as

$$T = \frac{D}{\sqrt{D}\left[\left(\frac{2C_1}{h}\right)^{\frac{1}{2}} + \frac{k}{t^{\frac{1}{2}}}\right]} = \frac{D^{\frac{1}{2}}}{\left[\left(\frac{2C_1}{h}\right)^{\frac{1}{2}} + \frac{k}{t^{\frac{1}{2}}}\right]} \qquad (5)$$

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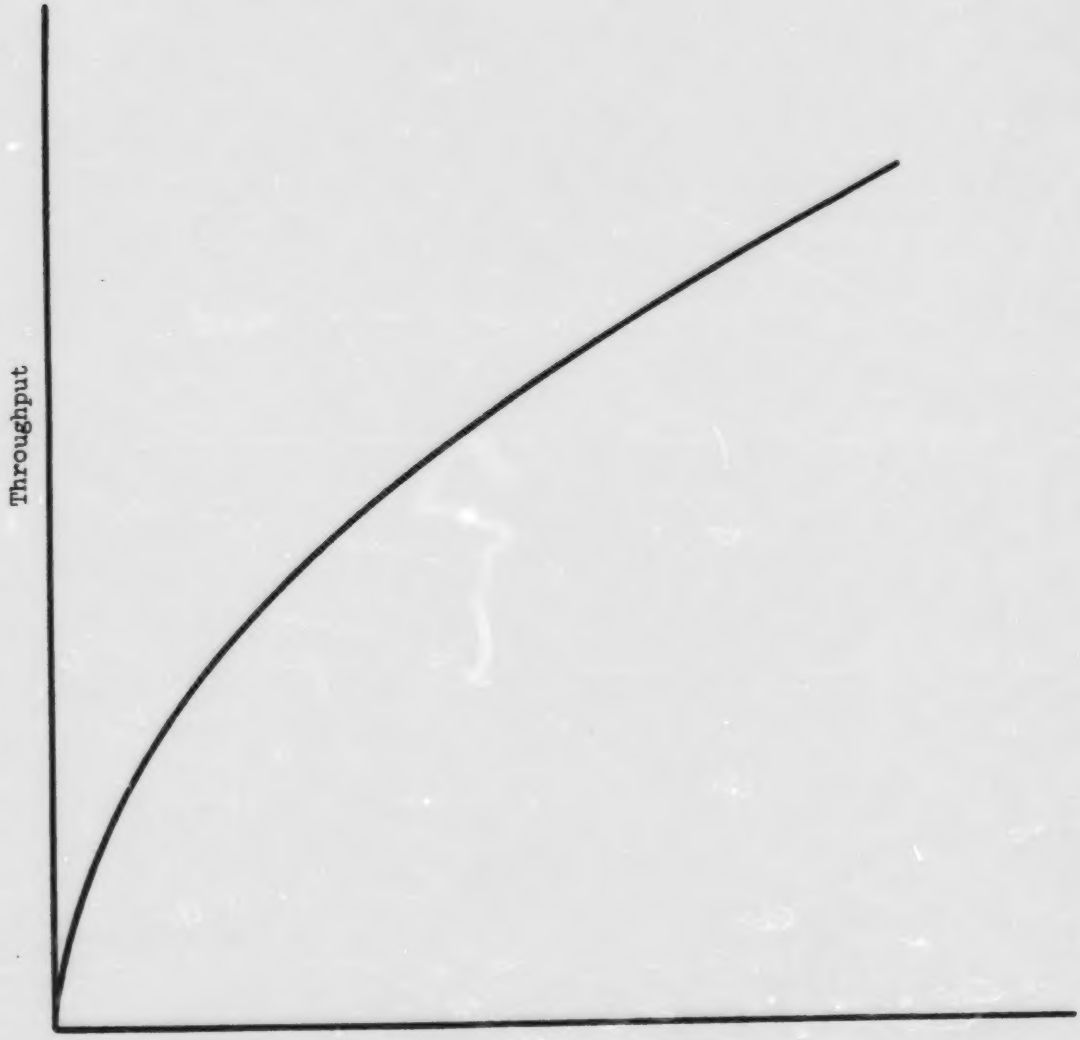
*J. Buchan and E. Koenigsberg, Scientific Inventory Theory, Prentice Hall, 1961.

Figure 26

THROUGHPUT DEMAND RELATIONSHIP



Inserting Equation (5) into Equation (1) we have the result that the space requirement is proportional to the square root of throughput or,

$$S = AD^{\frac{1}{2}}\left[\left(\frac{2C_1}{h}\right)^{\frac{1}{2}} + \frac{k}{t^{\frac{1}{2}}}\right] \qquad (6)$$

We note further that as the holding cost per unit increases (as for higher-value goods) the turnover increases and the space requirement decreases, and that as the safety factor increases (as for critical spare parts), the turnover decreases and the space requirement increases.

Similar results can be shown to hold for other inventory policies, including the "one-bin" replenishment policy and other "two-bin" policies. The results are only slightly modified when multiproduct inventories subject to some constraint are considered.

Using the results above, we see that turnover ratios are higher and space requirements are lower when inventory is concentrated in a distribution center than when it is spread over multiple locations. Thus all of the space-associated costs per unit of throughput in Table 39 are reduced. Similarly, the general and administrative costs per unit of throughput are reduced because management and office costs can be spread over a larger base. Depending on the initial scale of operations, handling costs per unit of throughput are reduced or remain the same -- making a large warehouse larger may not reduce handling costs.

In smaller warehouses, loading dock space and handling labor are not well utilized. As throughput volume increases, utilization increases significantly before staff must be added. The staff additions as throughput increases are initially for handling and order picking and then for clerical functions.

The analysis of the space required for a warehouse shows that it is proportional to the square root of annual demand. For example, if the annual demand increased by a factor of 4, the space requirement would only double. This argument only applies to a single client. (If a client had four small warehouses, he could combine the inventory in one warehouse that had half of the total area contained in the four.) It does not apply to a warehouse that serves several clients. A client's cargo should remain in one block or one specified area within the warehouse in order to facilitate storing and retrieving the cargo. Therefore any given client should have the same amount of storage space he would have if he operated his own warehouse. The candidate organizations are those whose space requirements are modest, say, at most 30,000 square feet. (The break point depends, of course, on commodity characteristics, market characteristics and other factors.) However, the same general principles of economy of scale are applicable to joint distribution centers.

First, the savings in actual storage space in a joint distribution center are not large. There is a potential for a slightly higher concentration of storage (and a lower space factor, A in Equation (1)) because the peak storage requirements of the several companies will not occur at the same time, and the area required for loading and unloading vehicles will not increase linearly with the total throughput. However, the construction and maintenance cost per unit of space will be lower because of economies of scale in construction and in the higher utilization of maintenance staff.

Second, the general and administrative costs and essential office costs will be less per unit of throughput because these costs will increase less than linearly with an increase in throughput. Joint operation or operation of a public distribution center does have an added cost of coordination but this should be less than the savings possible in management and administration costs.

Assuming the same technology, handling costs per unit of throughput will decrease with the size of the warehouse until an efficient size is attained. A larger distribution center can justify more handling equipment and probably more sophisticated handling equipment and thus reduce handling labor costs. This will occur when the various commodities have similar or related handling characteristics. In the absence of a detailed list of customers and commodities using a distribution center we cannot estimate the potential savings in joint operations.

By and large, public warehouses are not highly mechanized. There are several reasons for the lack of mechanization, many of which are valid for the distribution center. Given a wide variety of commodities and companies there is no single mechanized system which is optimal or near optimal for all. In many cases the customers are only committed to the warehouse for a relatively short time interval, too short to justify the capital cost of equipment. Many warehouses are in older, less versatile buildings which either add to the cost of mechanization or make some types of mechanization impossible.

Most of the recent developments in mechanization of distribution centers have been for relatively large companies and for large centralized distribution centers handling highly specialized products. The Autolite-Ford Parts Redistribution Center in Brownston Township, Michigan has 3,000,000 square feet of floor space (75,000,000 cubic feet of enclosed space). The GMC Truck and Coach Division spare parts center covers 1,000,000 square feet. In these distribution centers and in other centers, there are several distinct mechanized systems for handling subsets of the SKU's and for assembling different types of orders.

Before investing in mechanization and automation a distribution center must know its product mix and client requirements in detail. In the absence of such information the best alternative is high storage racks and a multiplicity of forklift types of warehouse storage and handling and several types of semimechanized packing lines and pre-loading areas.

Labor savings of considerable magnitude can be obtained by planning order picking rounds, assigning storage locations and warehouse vehicle assignments in a near-optimal manner. Marketing advantages can be attained by improving the distribution centers' order response time and its ability to assume responsibility for efficient transportation to the client's customers. It would appear, therefore, that initially there is more to be gained from investment in a modest computer installation (and associated software) for these functions than from investment in highly specialized mechanization.

On the basis of potential markets, in terms of commodities and cutomers, we have designed distribution centers of 100,000, 200,000 and 400,000 square feet of storage and working space plus the associated office space, truck and rail docks and ramps, and parking facilities. The centers are not automated; about 75 per cent of the goods are stored on pallet racks and most movements are by high-lift fork trucks. The buildings are 20 feet high, are of the concrete tilt-wall type and have separate doors and ramps for inbound and outbound movements. A drawing and the pertinent dimensions are included in Appendix G. Our analysis of construction and operating costs excludes the cost of land on either a purchase or rental basis. This can readily be added to the other costs once the site is selected.

High (18-foot) pallet racks were selected because of the diversity of products that a distribution center will handle. Full automation cannot be recommended at this time, and 12- to 15-foot limits are too restrictive. One or two 24-foot-high warehouses have been built, generally for individual companies; most designed to use pallet stackers. Without a detailed profile of the customer and his products the more flexible lift-truck system is preferred for the anticipated turnover.

The characteristics and costs of the three warehouses are described in Table 40. We have allowed an unusually large area for roadways and truck parking in order to insure freedom of flow space for temporary storage and moderate growth within the perimeter. For these calculations, considering a public facility serving a range of customers of moderate size, we have assumed the following:

1) 40 per cent of input stacked on original pallets; 60 per cent of input restacked.

2) 25 per cent of output on original pallets; 75 per cent of output on restacked pallets.

3) Average density 20 pounds per cubic foot.

4) Turnover 10-12 times per year.

5) 75 per cent of storage on pallet racks.

6) All loading and unloading of vehicles included.

7) Labor overhead of 21 per cent (average of a low of 16.2 per cent and a high of 27 per cent*).

8) A&G costs (including management, office, security, building and grounds maintenance) taken as 94 per cent (for small), 90 per cent (for medium) and 85 per cent (for large) of direct labor costs.**

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*Recent teamster contracts on West Coast.

**Digest of Warehouse Cost Calculations & Handling Standards, Market Publications, Inc., Washington, D.C.

Table 40

WAREHOUSE CHARACTERISTICS AND COSTS

	I	II	III
Annual Throughput	60-75,000 tons	120-150,000 tons	240-300,000 tons
Warehouse space, sq. ft.	100,000	200,000	400,000
Usable cube, cu. ft.	1,800,000	3,600,000	7,200,000
Lot size, sq. ft.	280,000	450,000	730,000
Office (air conditioned)	10,000	15,000	22,500
Dock area, sq. ft.	8,200	10,200	15,400
Parking area, sq. ft.	170,000	235,000	307,500
Railroad dock, sq. ft.	2,200	4,100	7,000
Construction Cost, $			
Warehouse	398,000	796,000	1,592,000
Office	188,000	267,000	377,000
Sprinklers	44,000	86,000	169,000
Dock area	31,000	38,000	57,000
Doors	25,000	31,000	47,000
Parking area	257,000	344,000	453,000
Railroad dock	13,000	23,000	39,000
Fencing	9,000	11,000	14,000
Steam heat	45,000	88,000	173,000
Total	1,010,000	1,684,000	2,921,000
Direct Labor, no.			
Fork operators	15-18	30-36	57-68
Warehousemen	22-27	44-53	82-101
Clerks	18-22	32-40	61-76
Operating Cost, $			
Buildings, etc.	318,000	530,000	919,000
Racks	15,000	30,000	60,000
Labor	1,237,000-1,506,000	2,340,000-2,485,000	4,276,000-5,237,000
Fork lifts	93,000- 110,000	173,000- 207,000	324,000- 380,000
Total Annual Operating Cost, $	1,663,000-1,949,000	3,073,000-3,613,000	5,580,000-6,597,000
Cost/ton of Throughput, $	27.70-26.00	25.60-24.10	23.25-22.00

9) Annual operating cost included capital cost at 15 per cent return on investment after taxes.

10) Land rental costs not included.

Labor rates in Montreal were obtained from a study carried out by Swan Wooster for CTC and are based on actual union contracts. Building costs in Montreal are from the Dodge reports.* Forklift costs, specifications and performance figures were obtained from Lifton, Inc., the Bay Area distributor for Clark Equipment. Storage rack specifications and costs were provided by a manufacturer, Lodi Fabricating Industries, Inc. Figures and performance were checked by contacting users. The land rental costs were not included because no specific site has been proposed.

The costs given in Table 40 are for the operating assumptions above. A warehouse with higher average density and higher turnover will have lower costs per ton (for example, a grocery chain warehouse of over 400,000 square feet with an average density of about 30 pounds per cubic foot and 13 turns a year has costs of about $15 a ton). A warehouse without order picking (full pallets in, full pallets out) will have considerably lower costs (a grocery manufacturer with goods of 35 to 40 pounds per square foot density, 10-11 turns a year, less than 5 per cent repalletized, reports costs of about $8 to $10 per ton). Small warehouses with almost all items repalletized have costs in excess of \$30.00 per ton, even in areas with labor costs about 25 per cent below those of Montreal.

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*Building Cost Calculator and Valuation Guide, April-June 1972, F. W. Dodge Co.

The effects of density and turnover are to increase the throughput in direct proportion. Thus, if the average density is 30 pounds per cubic foot instead of 20 pounds per cubic foot, the expected cost for a 200,000 square foot warehouse are:

$$\text{Throughput} = 120{,}000 \times \frac{30}{20} = 180{,}000$$

$$\text{Cost per ton} = \frac{\$3{,}073{,}000}{180{,}000} = \$17{,}000 \text{ per ton}$$

Repalletizing and placing inbound pallets requires four times as much labor per pallet as placing original pallets. Order picking, and palletizing and loading outbound goods requires five times the labor content of picking and loading an original pallet. These figures can be used as a first approximation in estimating the cost if inbound and/or outbound pallet/nonpallet proportions are changed. The ratio of labor required outbound to labor required inbound is about four to three.

Warehouse and terminal wages in Montreal are relatively high when compared with U.S. and Canada averages. If we assume that Montreal labor is 10 per cent more productive than comparable U.S. labor, then labor and forklift costs will be reduced by about 9.1 per cent (fewer will be required), and expected overall cost per ton will be reduced about 7.4 per cent (reduction ranging from \$2.05 to \$1.60 per ton).

Without a detailed survey of potential customers and their distribution needs we cannot estimate the optimal size of the Montreal distribution center. A distribution center serves customers, not commodities; and customer demands vary, even in the same industry. A customer survey is needed before site selection and design can proceed. Recognizing the commodities and the fact that large companies will continue to operate independent centers, the initial installation should only plan on a throughput of 100,000 to 150,000 tons per year or a storage area of about 200,000 square feet with options on additional acreage for future expansion.

Drayage and transportation

Drayage and transportation are generally considered part of the warehouse function even though it is treated as a specific account by most public warehouses. Generally the warehouse activity (and charges for service) begins with the unloading of a truck or railcar at the warehouse dock, and ends with either the delivery of an order to the consignee or the loading of a vehicle not controlled by the distribution company.

A company operating its own small warehouse and small truck fleet generally has the high costs of low vehicle and warehouse staff utilization and high transportation costs. As throughput increases, vehicle and staff utilization increases. While there are substitutes for company-owned vehicles (leased vehicles or a public drayage company), transportation costs for the small warehouse will be high in any event.

There are two scale trends which make transportation and local drayage attractive to a large joint distribution center. The first is the effect of the size on the utilization of vehicles and staff (applicable to a company-owned or joint distribution center). The second applies to the distribution company -- by controlling the movement of goods for many clients, it can plan loads and routes which optimize the use of the fleet while meeting the service standards set by the clients. This advantage applies to over-the-road shipments as well as local drayage (pickup and delivery), given a large enough volume.

Cartage and over-the-road transportation are not notably profitable businesses. Their greatest profit potential comes from their integration with the other functions of the distribution center. This potential, particularly in the case of over-the-road transportation from the distribution center to more distant service areas, can be enhanced by the potential for return journeys with goods destined for the distribution center or for clients of the distribution center. The distribution center can also organize shipments for several distributors to a single consignee. Higher vehicle utilization and larger loads per vehicle are possible with an efficient multiclient distribution center.

The pickup and delivery operation (PUD) can typically be made more efficient by increasing the average shipment size (decreasing the number of stops), increasing the average speed of the vehicle through better routing, increasing the number of shipments carried for a given distance, or increasing the annual utilization of the equipment. The latter case results only in modest savings because the PUD operation is essentially direct-labor-intensive with the resulting low proportion of fixed to variable costs.

The analysis of pickup and delivery costs below is based on a 1962 California Trucking Association report*, and are based upon a two-axle truck with an estimated 1972 purchase price of $5,526. The estimated 1972 average hourly compensation for a driver is taken as $6.27, which includes fringe benefits. The costs shown in the CTA study were updated by escalating the labor and material component factors by 60 per cent and 20 per cent, respectively, using Bureau of Labor Statistics data.

The ratio of direct to indirect costs was taken as 4 to 1. Indirect costs were included by increasing direct costs by 25 per cent. An operating ratio of 0.9 was used, which, when combined with the indirect cost adjustment percentage of 25 per cent, yielded a direct cost to revenue ratio of 1 to 1.39.

The revenues from varying types of PUD operations were developed from the following equations. A constructive approach was used to generate the PUD cost equation. That is, the costs were functionally related to their associated activities. Basic to this was the estimate of time a PUD truck spent running and the time spent stopped for loading-discharging. The running time in hours (T_r) is the round-trip distance (D) divided by the average speed (V) or,

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*"Report on a Study of the Cost of Transportation Property in California by Motor Vehicle Equipment." California Trucking Association.

$$T_r = D/V \tag{7}$$

The stop time in hours (T_s) is related to the average shipment size ($\bar{S}$) and the total weight (W) to be picked up and delivered per round trip (both in pounds). From the CTA report, a function was statistically derived ($r^2 = 0.988$, $F = 71$) which related vehicle productivity (K) in pounds per hour when loading-discharging to the average shipment size ($\bar{S}$). This relationship is,

$$K = 109(\bar{S})^{0.48} \tag{8}$$

From Equation (8) the total time spent stopped per round trip (T_s) can be given by

$$T_s = W/K \tag{9}$$

From these productivity equations we obtain the cost equation

$$\begin{aligned} C = 1.39\ \{&(W_D)(T_r + T_s) \\ &+ (0.45)(I_T)[(T_r + T_s)/(H_y \cdot L_y) + (D)/(366{,}000)] \\ &+ (L)(T_r + T_s)/(H_y) \\ &+ (M)(D)\} \end{aligned} \tag{10}$$

where C = Total cost per round trip, \$

1.39 = Combined operating ratio and indirect factor

W_D = Driver's hourly earnings (\$6.27), \$/hour

0.45 = Depreciation factor which incorporates a 10 per cent salvage value and assumes that 50 per cent of depreciation is independent of mileage and 50 per cent is directly related to mileage driven

I_T = Purchase price of a truck ($5,526), $

H_y = Hours per year truck is utilized, (average = 1,525)

L_y = Life of the vehicle in years, (6 years)

366,000 = Maximum life of vehicle in miles

L = Annual license and registration fees ($163), $/year

M = Mileage costs for gas, oil, tires, and maintenance and repair ($0.11), $/mile

D, T_s, T_r = Distance, time stopped, time running

Equation (10) was used to develop the following five figures. In Figure 27, the cost per hundredweight ($/cwt) is plotted against shipment size for varying distances. Figure 28 shows the impact of average speeds for a 100-mile round trip. Figure 29 shows the impact of weight carried per round trip by shipment size for a 100-mile round trip at an average speed of 25 miles per hour. Figure 30 shows the cost impact of varying the hours of annual vehicle utilization. As can be seen, doubling vehicle utilization will only reduce costs by 2 per cent.

Figure 31 shows the combined round-trip weight, distance, and speed comparative costs for a 100- and 500-pound average shipment size.

Figure 27

IMPACT OF DISTANCE
($/Cwt)

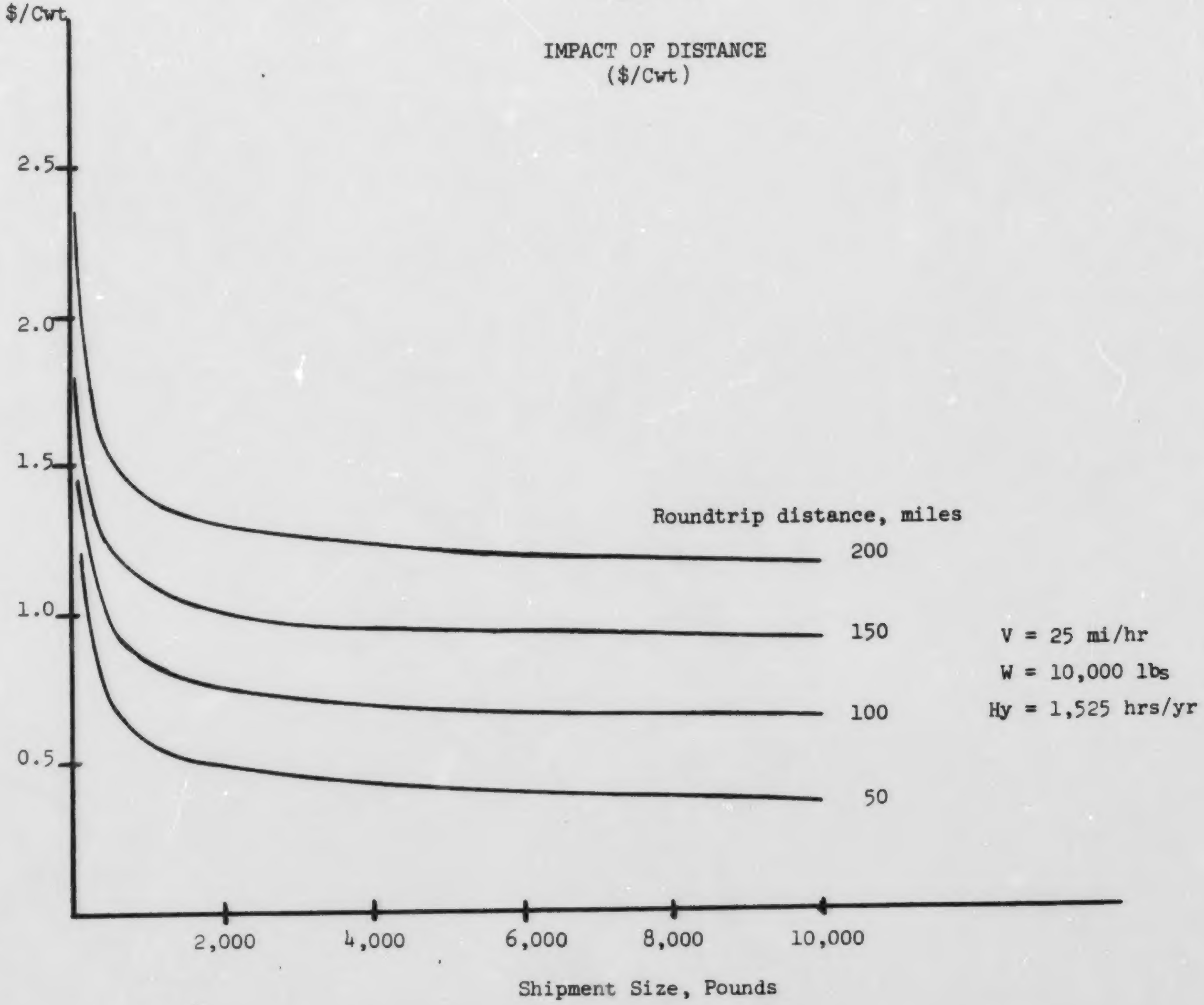


Figure 28

IMPACT OF SPEED
($/Cwt)

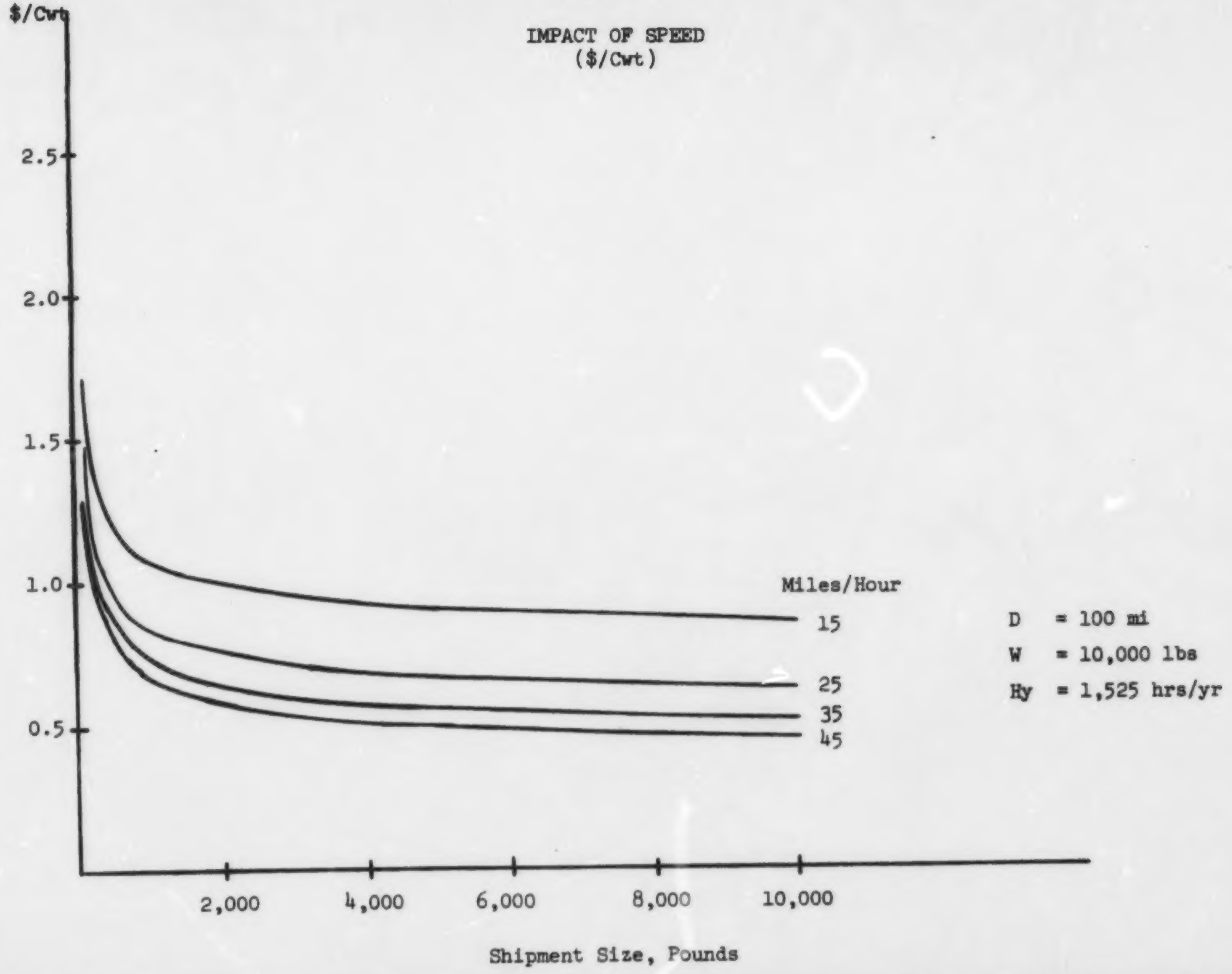


Figure 29

IMPACT OF ROUND-TRIP WEIGHT
($/Cwt)

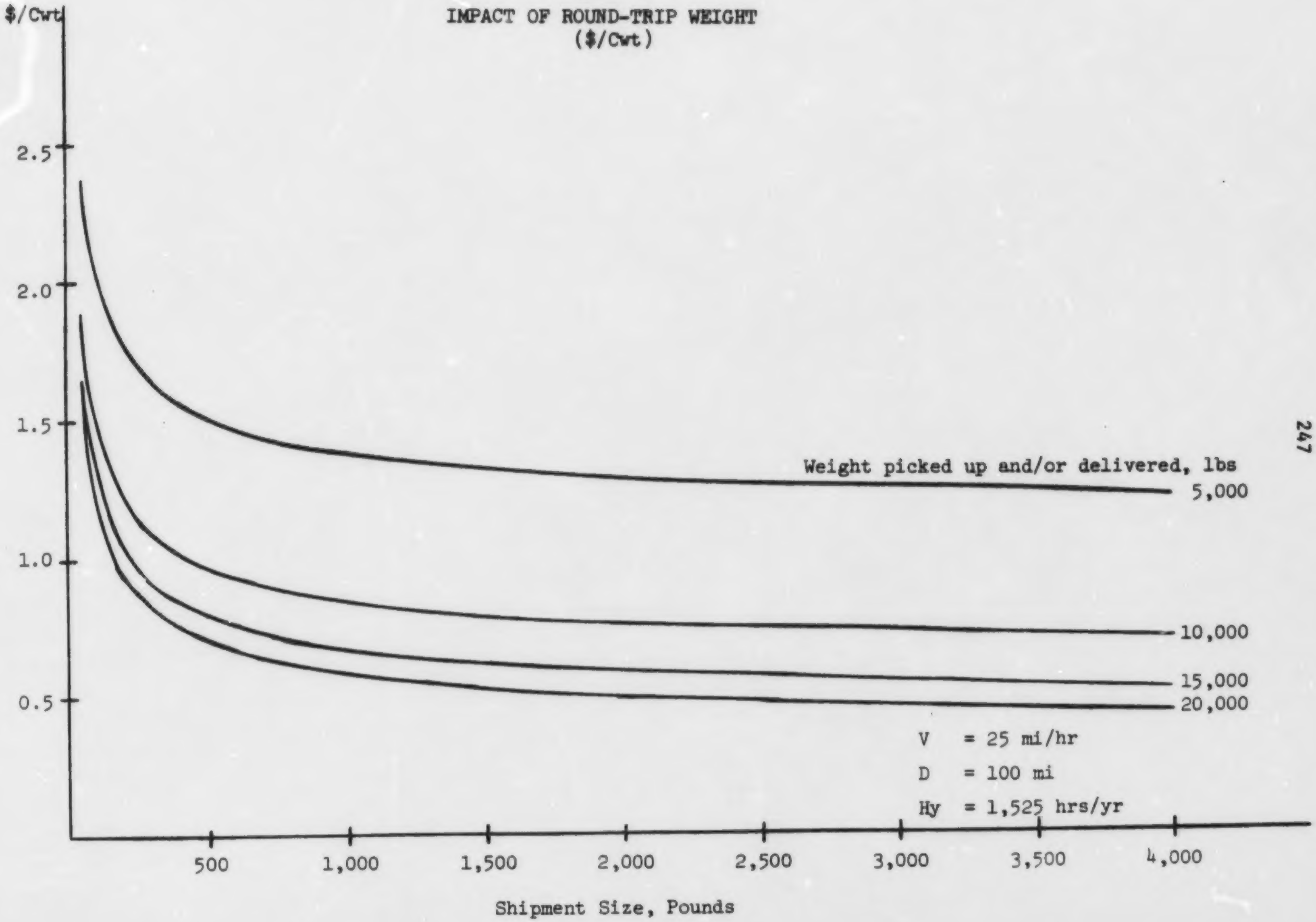


Figure 30

IMPACT OF INCREASED ANNUAL VEHICLE UTILIZATION
(INDEXED UPON THE TOTAL ROUND-TRIP COST)

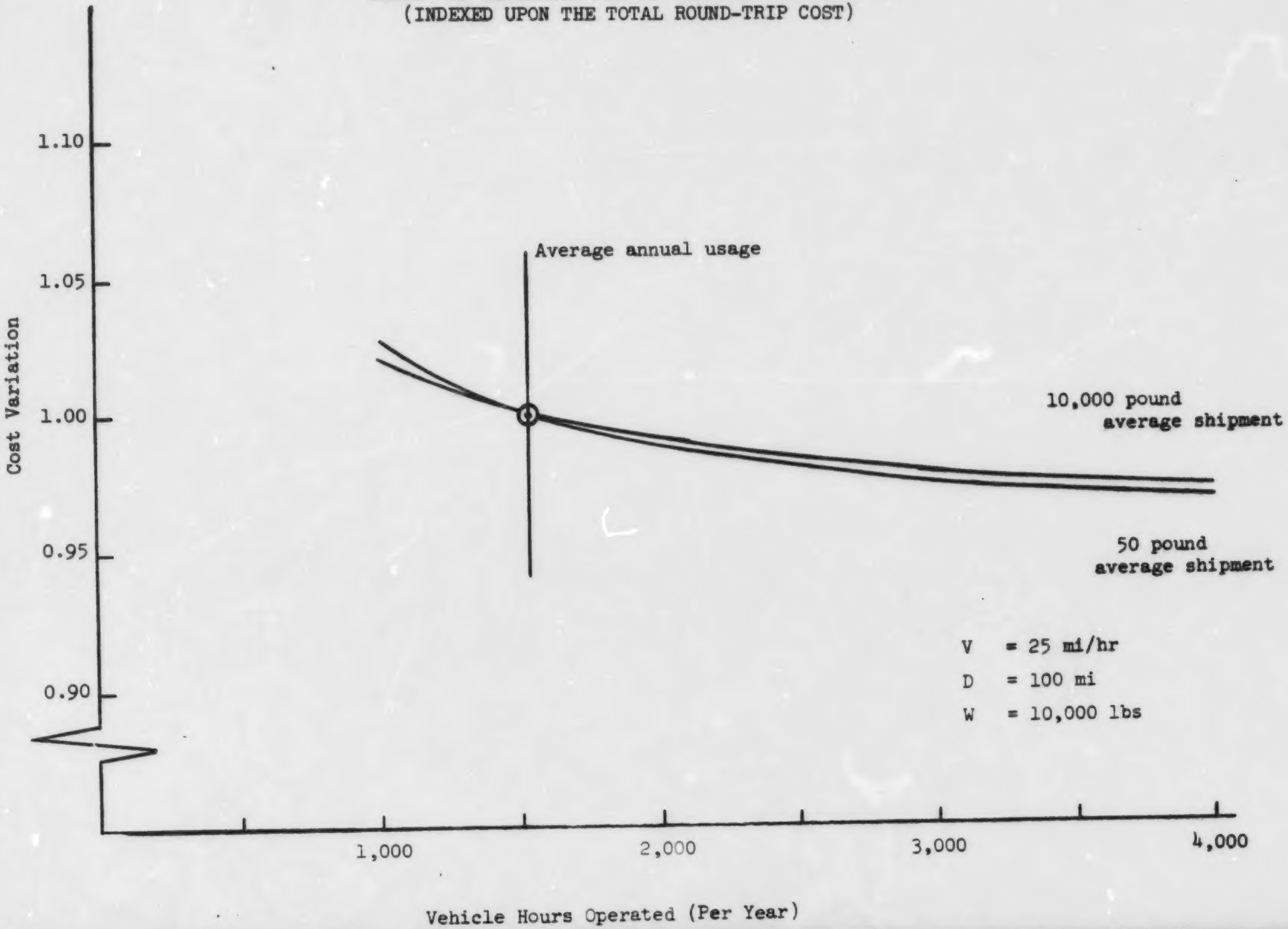
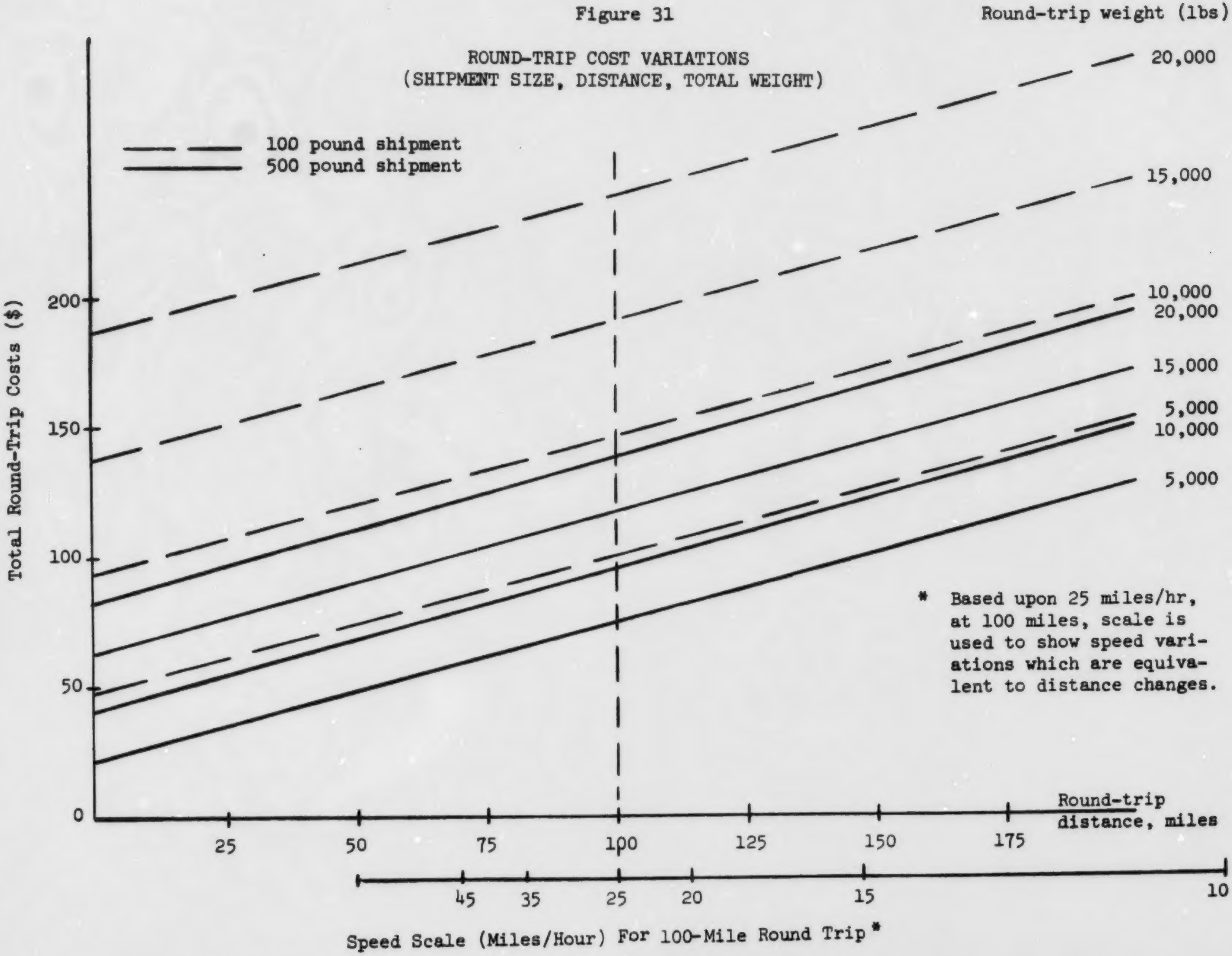


Figure 31

ROUND-TRIP COST VARIATIONS
(SHIPMENT SIZE, DISTANCE, TOTAL WEIGHT)



* Based upon 25 miles/hr, at 100 miles, scale is used to show speed variations which are equivalent to distance changes.

We find, therefore, that significant savings are possible in a PUD system controlled by the distribution company. The largest savings, perhaps, arise from the increase in average weight delivered per truck stop. If this average increases from 100 pounds to 500 pounds, delivery costs can be reduced by a third. The second largest saving arises from the potential for improved routing of a larger fleet which will increase the load per vehicle and result in lower cost per unit of weight.

In Canada, labor costs are somewhat less than those in the United States and vehicle costs are higher. Because PUD is labor-intensive, the ratio of labor costs to capital costs is somewhat less and the cost savings potential is reduced. Nevertheless, significant cost savings, in excess of 10 per cent, are possible. The lower ratio of labor to capital costs also implies that the savings due to higher vehicle utilization are higher, say 3 or 4 per cent instead of 2 per cent.

The distribution company can also reduce line-haul (intercity) truck costs. The analysis below is based on truck line-haul costs taken from the CTA study for truckload (TL) and less-than-truckload (LTL) shipments and escalated by 50 per cent to approximate 1972 price levels. The costs and load factors were given for 200-, 400- and 700-mile trips. An examination of comparable ICC data for 1966 and 1968* giving weight carried versus length of haul revealed a statistical correlation between weight and distance. Two least-squares regression equations were derived from the 1966 and 1968 ICC data respectively. The same slope and intercept appeared in each equation, resulting in the relationship

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*Cost of Transporting Freight by Class I and Class II Motor Common Carriers of General Commodities, 1966 and 1968.

$$W = 3,100(D)^{0.34} \tag{11}$$

where W = weight aboard the vehicle, pounds

D = distance of haul, miles

Figure 32 shows the weight-versus-distance relationships from the ICC and CTA reports. At 200 miles the ICC and CTA curves intersect, indicating that at this distance the average trucking firm carries virtually all LTL shipments. As the distance increases, the proportion of LTL shipments decreases.

Figure 33 shows the average line-haul costs in dollars per hundredweight as a function of distance. This cost was developed by taking the implied proportion of LTL to TL shipments based upon average weight for each distance and applying this proportion against LTL and TL costs from the CTA report. The cost derivation is given as:

$$a = (W_A - W_{TL})/(W_{LTL} - W_{TL}) \tag{12}$$

$$CA = aC_{LTL} + (1 - a)C_{TL} \tag{13}$$

where a = fraction of shipments which are LTL ($a \leq 1$)

W_A = average line-haul weight carried, all shipments, pounds

W_{TL} = average TL line-haul weight carried, all TL shipments, pounds

Figure 32

WEIGHT CARRIED VERSUS LENGTH OF HAUL

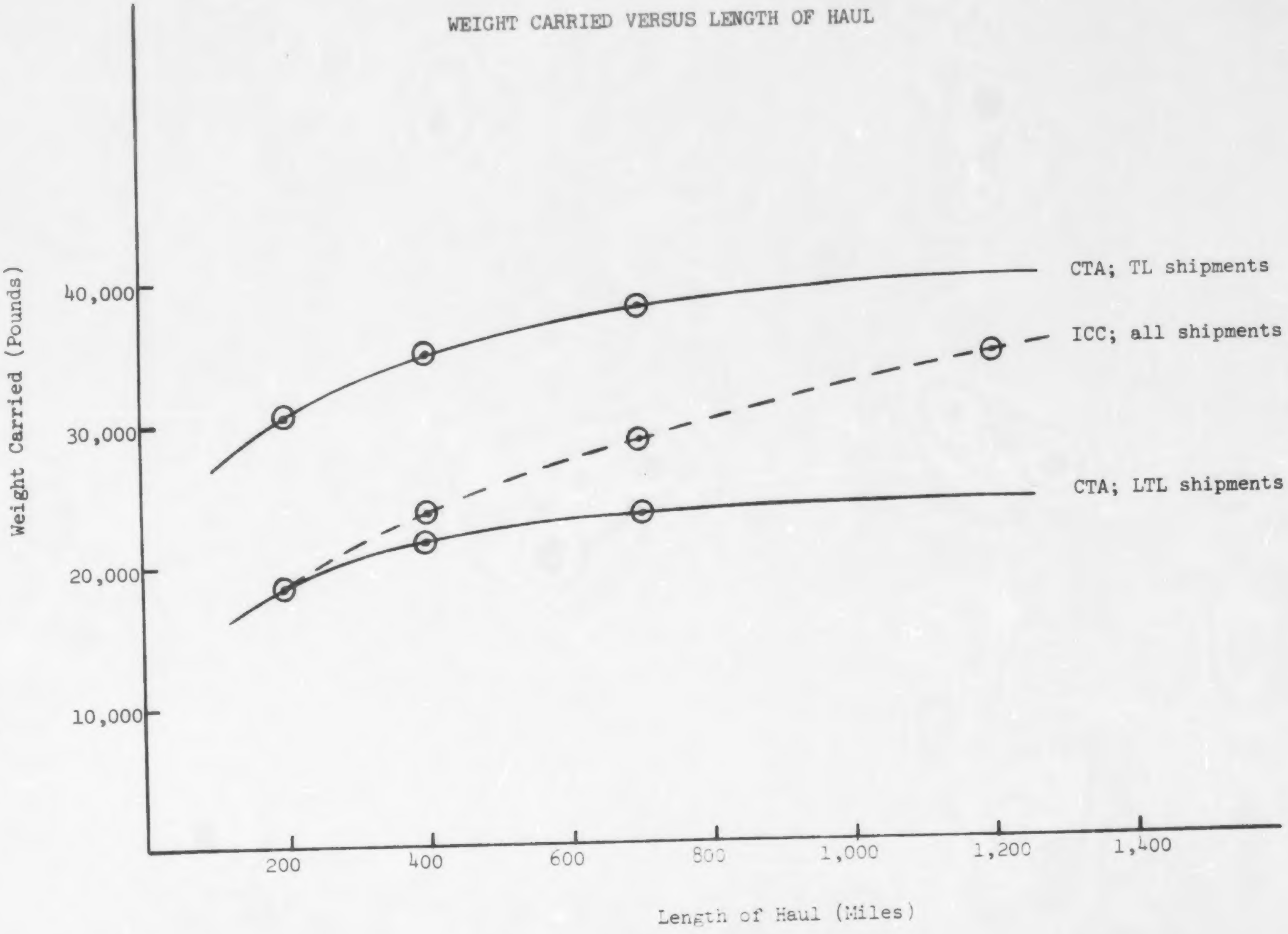
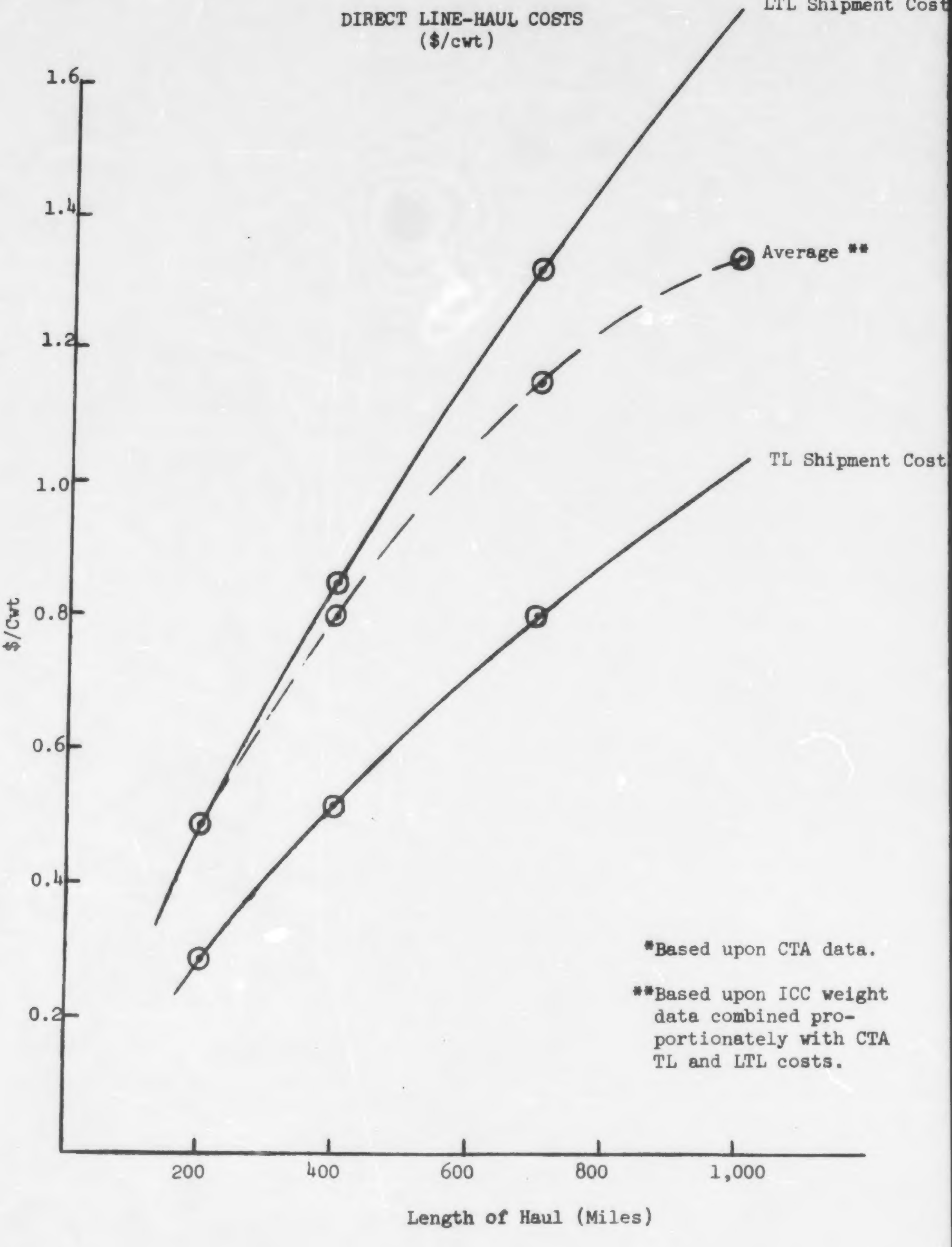


Figure 33

DIRECT LINE-HAUL COSTS
($/cwt)



*Based upon CTA data.

**Based upon ICC weight data combined proportionately with CTA TL and LTL costs.

W_{LTL} = average LTL line-haul weight carried, all LTL shipments, pounds

C_A = average cost per hundredweight, all shipments, \$/cwt

C_{TL} = average cost per hundredweight, TL shipments, \$/cwt

C_{LTL} = average cost per hundredweight, LTL shipments, \$/cwt

Domestic shipments to the distribution center will generally be by full truckload or in large shipments -- (as well as by rail, water and, to some small extent, air). If the distribution center has the throughput to move distant locations to carry full truckloads of goods from several clients to a single destination it could provide a service that is essentially truckload at a lower cost than public carrier LTL movements. These cost savings may be as large as 50 per cent for distances up to 500 miles falling to 25 per cent savings at 1,000 miles. Given the prime market region for the Montreal distribution center there will be little volume for destinations more than 500 miles from Montreal. A conservative goal for distribution center truckload savings should be a minimum of 25 per cent.

Auxiliary physical and information services

We have estimated the markets for the auxiliary physical and information services. These services must be self-supporting in the sense that revenues gained from these services are equal to or greater than the costs (or at least the marginal costs) of providing these services. The equipments needed for these services are a function of the operations to be performed, the commodities and customer mix.

The largest potential for auxiliary services lies in management information systems. This service is ideal because the distribution company will need a computer to assist in its own operations. Therefore, a broad range of information services can be provided at little additional cost. A moderate-sized computer will be able to provide a full range of information services for about $2 per shipment (illustrating the low cost of providing auxiliary management services). (The cost of the information systems required for internal use are included in the costs shown in Table 40.)

Transportation Interface

Ideally, the distribution center will be located near truck, rail, water and air transportation networks. Trucks will probably move more tonnage in and out of the center than all the modes combined followed by (in order of importance) rail, water and air. As we indicated above, a large distribution center could process the following tonnages annually by 1975.

	Tons
Canadian domestic	250,000
Canada - U.S.	2,000
U.S. - Canada	10,000
Foreign imports*	9,000
TOTAL	271,000

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*Excluding shipments from the United States.

Canadian domestic cargo is largely cargo destined for customers in the Montreal region and hence will be delivered by truck. A large proportion of this cargo will also arrive by truck. An analysis of domestic cargo movements within Canada shows that 143,000,000 tons moved by rail* and 120,000,000 tons moved by truck,** The rail movements include bulk and semibulk cargoes such as grain, lumber products and steel which are not candidate commodities for the distribution company. Further, much of the cargo will come from the Toronto region and therefore is more likely to arrive by truck than cargo coming from the western provinces. Therefore, a reasonable estimate is that about 75 per cent of the Canadian domestic cargo will arrive at the distribution center by truck, the balance largely by rail.

We do not foresee a significant proportion of foreign imports destined for Canada or the U.S. arriving by air. If cargo arrived by air and then went to the distribution company for storage, the need for fast shipment by air would be negated. Obviously some cargoes requiring the auxiliary services provided by the distribution company, such as display materials, and some emergency shipments will arrive by air but the total tonnage will be small, amounting to 10 per cent of the total or less. We expect rather that the foreign cargoes will arrive by water, most likely in containers. Unless the distribution center is actually located on the pier (or can be served directly by a waterborne feeder) the foreign cargo will arrive at the center by truck in a condition resembling a long-haul truck movement. The cargo destined for customers in the Montreal region and Region C of the United States will obviously be delivered by truck. The remaining foreign cargo will be delivered by truck, rail and air.

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*"Waybill Analysis: Carload All-Rail Traffic, 1968," CTC Table 1.

**"Road Transport Bulletin, Volume 1." No. 3, DBS Table 2.

Therefore, we expect that 900 tons of the foreign imports will be delivered to the distribution center on air transport pallets if the center is located on the airport premises; otherwise it will be delivered by local truck. The remaining 8,100 tons will be delivered by long-haul truck (actually ocean containers). The foreign imports destined for U.S. customers, about 30 per cent or 2,700 tons (see page 181), will be delivered by long-haul trucks. The imports destined for Montreal, 54 per cent or 4,900 tons, will be delivered by local truck. Most of the remaining 1,400 tons destined for the eastern CMA's will be delivered by long-haul truck, the balance by rail except for a small amount by air. The diversion between modes will probably be about 1,000 tons by truck, 200 tons by rail and 100 tons by air.

Cargo moving through the distribution center from Canadian sources to U.S. customers will be delivered by long-haul truck since most of the U.S. customers are in Region C of Figure 7. About 75 per cent of this cargo will arrive at the distribution center by truck -- the balance by rail.

The cargo from U.S. locations for Canadian customers will be principally destined for customers in the Montreal region. As such, this cargo will be delivered by local truck. The cargo will arrive by rail and long-haul truck and the ratios will probably be something like 60 per cent by rail, 40 per cent by truck.

Summing up these rough estimates of cargo movements to and from the distribution center, we find the following division between modes:

	Incoming ST	Outgoing ST
Local truck	-	264,900
Line-haul truck	201,100	5,700
Rail	69,000	300
Air	900	100
TOTAL	271,000	271,000

These figures indicate the business opportunity in providing local drayage. If we assume that most shipments are currently about 2,500 pounds and that the average truck delivers two shipments per trip and further assume that the distribution center, through better route planning, can increase the average to four shipments per truck trip, the local delivery costs would be reduced by almost $10 per ton (see Figure 29). If we assume that the average shipment size is currently about 4,000 pounds and make the same assumptions concerning number of shipments per trip, the distribution center could reduce delivery costs by about $6.00 per ton. Actually, the delivery costs from a distribution center would be even greater since the average shipment size from the distribution center should be considerably larger than the average shipment size from smaller, private warehouses. In any event, it is safe to assume that a distribution center can lower delivery costs by at least $3.00 per ton if the center controls or operates its own fleet of delivery trucks.

Organization and Control

There are many different organizational structures that could be used by the distribution company. The exact structure and the resulting control mechanism will be a function of the capabilities and operating styles of the individuals employed by the distribution center. Therefore, the following discussion, based on the experience of the Manalytics staff in relevant industries, should be treated as a guideline rather than firm recommendations.

Organizational structure

The distribution company structure will have three main divisions: operations, administration and sales. The duties and the structure of the operations division are most important to the success of the distribution company and are discussed below. The administration division has the responsibility for the general and administrative items in Table 39 as well as rent, building maintenance, protection, labor relations, etc. Therefore, it is concerned with the day-to-day operation of the physical plant but does not have responsibility for handling cargo in the center.

The sales branch is responsible for developing new business and extending the service packages of existing customers for the distribution company. To do this, the sales department must have adequate information from the operations division in order to be able to estimate the cost of providing various services for negotiating with prospective clients. The salesman in some distribution organizations is the principal contact for the clients after a working agreement has been established, on the grounds that this relationship provides continuity. Further, the salesman is usually kept aware of the costs of providing the services requested by the client so that he will be able to make any adjustments in the working agreement that may be required. However, this arrangement has its disadvantages. A client will have to conduct business with the distribution company almost on a day-to-day basis after the working agreement has been reached. This business will consist largely of determining schedules of cargo moving into and out of the distribution center. Since these schedules are dependent on the availability of the labor and equipment in the operations division, the salesman cannot set schedules or promise delivery dates without consulting that division. If he does, the schedule of the operations division may be adversely affected. Since the operating division must be consulted on matters relating to schedules, it is the logical entity to receive and reply to client inquiries of this nature.

If the operations division handles customer relations pertaining to cargo handling and scheduling after the working agreement has been established, the division will be able to operate at maximum efficiency. However, the client may feel uneasy at being shunted from a man (the salesman) who has won his confidence, to a man (in the operations dividion) who gives the distribution company a higher priority than he gives the client. More important, however, is the effect on the salesman. If his relationship ends after the sale is made, he may become more interested in making sales than in developing long-lasting and profitable clients for the distribution company. Therefore, there are advantages and disadvantages to either arrangement.

The cargo-handling cost in the distribution company will be lower than a client would realize if he attempted to establish his own distribution center. The distribution company's lower costs come about through higher throughput which in turn minimizes peak work loads and allows more efficient scheduling of men and equipment. If anything jeopardizes this scheduling, the distribution company loses one of its advantages. Therefore, we believe the customer contacts relating to scheduling the cargo-handling, etc. should be under the direct control of the operations division. Even though the contact is shifted to the operations division, the client can be assigned to a single individual within the division and hence develop a new personal relationship.

The operations division should have five departments: client contact (scheduling) discussed above; warehouse operations; transportation; special operations; and maintenance. The warehouse operations would be responsible for receipt, warehousing, order picking, shipment and auxiliary services (packaging, marking, assembly) which do not require skilled labor. The warehouse department would use labor that did not have specialized or specific skills and the work crews would rotate from job to job as required (that is, from receiving to order picking, etc.). The warehouse crews would be able to perform those auxiliary services which do not require highly skilled labor and which do not have sufficient demand to justify a full-time crew. Consider, for example, a client who stored bulk liquid soap at the distribution center and requested the distribution center to bottle the soap in a variety of sizes and labels. If the client does not have sufficient volume to operate the bottling equipment full time and if the equipment is simple enough so that it can be operated by unskilled labor, the warehouse department could assign men to operate the equipment in periods of low activity.

The transportation department would be responsible for the operation of the truck fleet controlled by the distribution company. The transportation department could be combined with the warehouse department if union rules permitted. But since the transportation department will require safe, skilled drivers who are familiar with the areas they serve, there would be little intermingling of the warehouse and transportation crews. Therefore, there is probably little to be gained by combining the two departments.

The special operations department will perform the auxiliary services such as packaging, marking and assembly that require specialized skills or have sufficient demand to justify a full-time crew. For example, if the soap-bottling client described in the example above had sufficient volume to operate the equipment on a full-time basis, the service would be performed by the special-operations department. Other services requiring special skills, such as sewing machine operators performing a tagging service, would also be assigned to this department. In special cases, members of this department may also perform the order-picking function. If the department had a large section devoted to tagging clothing apparel (sewing in brand names), the section could perform the order-picking function in order to prevent delays that might otherwise occur if the warehouse crews were responsible. Careful planning would be required to insure that clothing is located in a position within the warehouse area so that the section can order-pick without interferring with the work being done by the warehouse crews.

The maintenance department would be responsible for the maintenance of the equipment used by the operations division. The major proportion of the work performed by this department would be the periodic overhaul of the trucks used by the transportation department and the forklift etc. used by the warehouse department.

The client contact department is the key to profitable operations. This department's prime responsibility will be to schedule the work crews within the center itself and to schedule delivery truck routes if the company has its own fleet. The primary purpose of this department will be to minimize the idle time of men and equipment while keeping customers happy. In effect, the department must schedule activities in such a way as to smooth out the peaks in work loads. For example, if the department, through poor scheduling, reduces productivity by 10 per cent because of increased idle time, the total cost of processing a ton of cargo will increase by about 7 per cent (see page 200). The importance of this department cannot be stressed too strongly.

Control system

Normal control systems can be applied for such items as accounting, security, etc. and will not be discussed here. The only control system that is of special interest to the concept of a distribution center is the system which governs movement of cargo within the distribution center. There are two events which could initiate the movement of goods: arrival of incoming cargo and receipt of a bona fide request for cargo.

When the customer contact department receives notification that cargo will be arriving at some future time, the department must determine the estimated time of arrival, the mode of transport, the tonnage of the commodities, and the condition of the cargo (on pallets, loose stowed, etc.). The department must:

1) Decide where the cargo is to be stowed in the warehouse.

2) Schedule and assign the incoming vehicle to an unloading position.

3) Assign the work crew to unload the truck.

When the incoming cargo arrives at the gate, security calls the customer contact department to obtain the information necessary to instruct the driver where to go. A document is then issued to the work crew giving them the necessary information for unloading and storing the cargo.

When a request is made for cargo, the customer contact department must first ascertain that the request is bona fide. If not, the customer would be directed to the responsible party. If it is, the department must determine if the cargo is available in the warehouse area and, if so, where; and determine where the cargo is to be delivered and at what time. The department then must schedule the delivery truck to be used, estimate the time required for order picking, assembly and truck loading and schedule the work crew accordingly.

These procedures are simple in concept but difficult to implement. If the distribution center has annual throughput of 271,000 tons, an average of about 80 line-haul trucks will be emptied daily (assuming a five-day week, 10 tons per truck) and about 200 local delivery trucks will be loaded daily (assuming a five-day week, 5 tons per truck). These figures illustrate the magnitude of the scheduling effort. Incoming trucks will arrive without prior notice. The consignee will also arrive without prior notice (with his own truck) demanding cargo. These unexpected arrivals should be accommodated and turned away only as a last resort.

The customer contact department's scheduling routine should be robust enough that project schedules can be modified almost on an hour-by-hour basis to accommodate unexpected arrivals, delays, etc. We suggest the scheduling be computerized because of the magnitude of the effort and the necessity for frequent updating.

The major scheduling effort will take place after the close of business hours. At this time, the schedule can be set and remain unchanged through the first few working hours of the next day shift. The night crews can be scheduled to perform the order picking and loading of the delivery vehicles for the first round of deliveries the next day. This would entail route planning for the next day's deliveries as well as scheduling the night crews. Second loads for those delivery trucks that can make more than one delivery during the day can be order picked, consolidated and stored near the loading docks to await the delivery vehicle. Deliveries to customers using their own vehicles would be treated in this manner as well. Thus, most of the order picking, consolidating and storing near the loading dock can be performed during the night shift.

A tentative schedule for the day shift of the warehouse crews will also be made after the close of business hours. This schedule will assign men to loading docks for unloading incoming trucks as well as assigning the trucks to specific loading docks. This schedule will be modified as the day progresses, because of the uncertainties involved.

This arrangement of unloading principally during the day and loading principally at night means that the warehouse night shift employment will be greater than the day shift employment. However, this arrangement is desirable because it minimizes congestion in the warehouse area and maximizes the utilization of the delivery truck fleet.

The control procedures for incoming goods will be different from the procedures for outgoing goods. Considering incoming cargo and, for illustrative purposes, assuming the cargo arrives by truck, a document is cut at the time of notification of the arrival of the cargo, listing the client, the mode of transport (including carrier's name), a description of the cargo, warehouse storage location and the assigned truck dock (for unloading). The document is delivered to the guard shack. The document is given to the truck driver and accompanies the cargo until it is stored in the distribution center. The important controls are:

1) Trucks are not allowed on the premises without a valid document.

2) The cargo is not removed from the unloading dock without being checked.

3) Cargo is stored using the instructions on the document.

4) The truck is not allowed to leave the premises without a valid document.

As the document moves from one position to another it triggers an activity The document itself (with any exceptions noted) is used to update the data bank on the cargo held in the center.

The controls of incoming cargo are oriented toward a truck (or railcar) load of cargo. The controls of outgoing cargo are oriented toward commodities. Order picking should be assigned areas within the storage area in order to reduce the congestion and because knowledge of a particular client's cargo is beneficial. The order pickers are given sequential lists of cargo and the consolidating station where it is to be delivered. There the cargo is checked and palletized and delivered to a loading station. There the cargo is checked and loaded in proper order or set aside to await the arrival of the truck (or railcar). The controls on customer vehicles (with outbound cargo) are the same as described above. Hence, there are three sets of outbound documents; cargo, pallet and shipment. Cargo is checked as it moves from one stage to another and the shipment document is used to update the data bank on cargo held in the center.

Feasibility Analysis

The economic viability of a distribution center is a function of the annual throughput. It is obvious from the data presented in Table 40 that unit costs vary almost linearly over the ranges of throughput analyzed. Labor (per ton of throughput) does not vary significantly over the range analyzed. The costs will begin to increase significantly if the throughput drops below 30,000 to 40,000 tons. We judge that the minimum feasible throughput for an economically viable distribution center is about 50,000 tons per year.

The location of the distribution center is important because of the cost of transportation between the center and the receiving customer. The distribution center can lower delivery costs through more efficient utilization of the delivery truck fleet. This reduction can be eleminated if the location of the distribution center significantly increases the delivery distance. Hence, the location of the center is important to the success of the distribution company. As we indicated earlier in this chapter, we do not anticipate that significant quantities of air cargo or water import cargo will move through the distribution center. We have also stated that a distribution center located at the new Montreal airport will not induce shippers to route significant cargo volumes through the airport. Similarly, we do not believe that locating the distribution center at the airport will induce significant volumes of air cargo to move through the distribution center. Since there appears to be no real advantage to locating the distribution center at the airport, the center may be more profitably located near to customers and rail and transportation networks. A market survey must be conducted to determine the potential customers, their locations and potential throughput. The economic feasibility of a distribution center cannot be determined until the results of the detailed market survey is available.

Summary

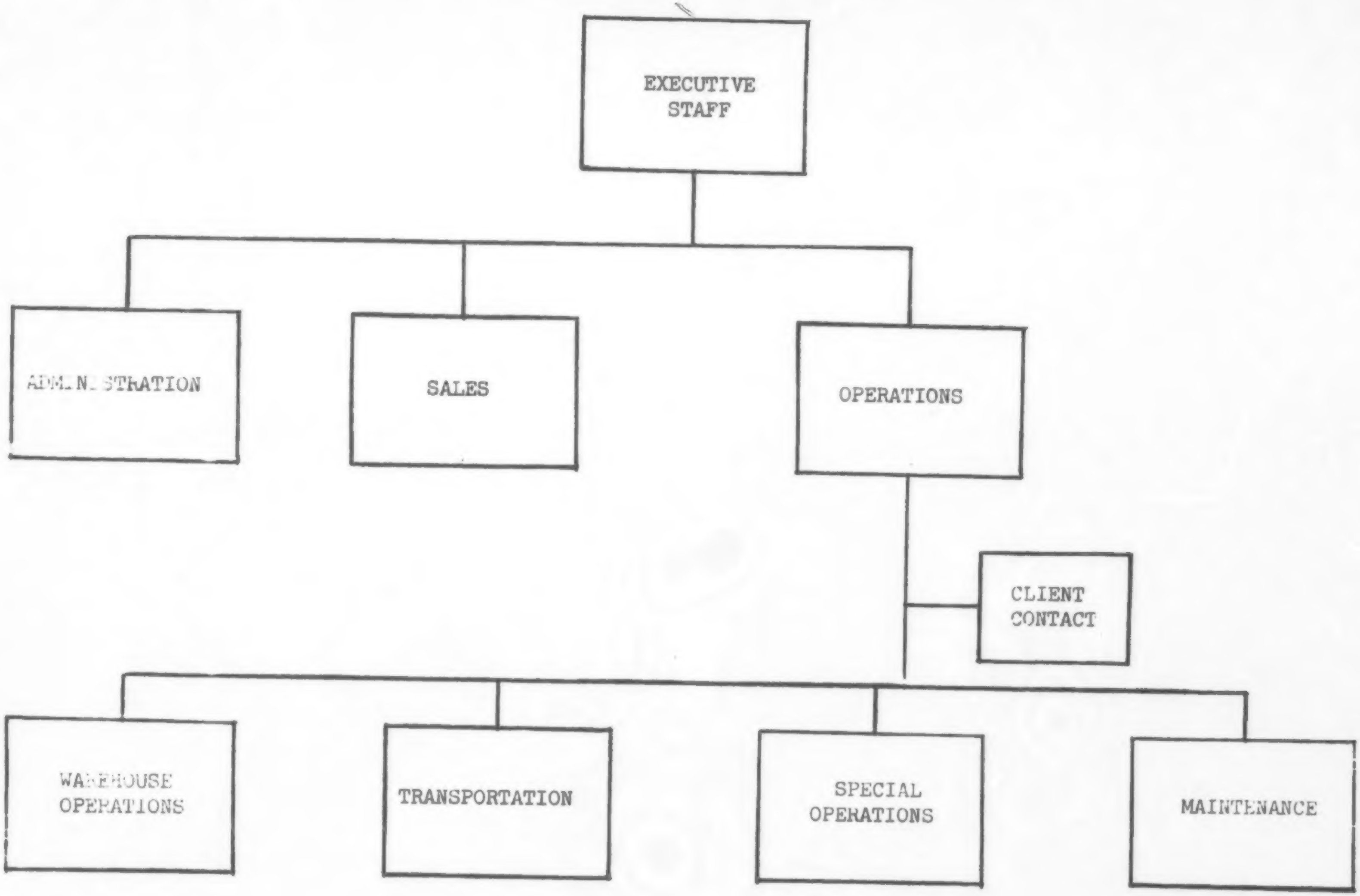
We have discussed many facets of a distribution company in this chapter, most of which cannot be summarized in a few short sentences. We did analyze the market for a distribution center and concluded that a center could have a throughput as high as 271,000 tons by 1975. However, a detailed market (customer) survey will be required to verify this figure. Because of the uncertainties involved, we suggest that a target of 100,000 to 150,000 tons be set and used as a foundation when conducting the detailed market survey.

The detailed market survey should determine specific shippers which have market volumes, commodities and distribution networks that could benefit from a large distribution center. The basic output of the study would be a more accurate estimate of the throughput of the terminal. Additionally, information on the commodities, shipping patterns and anticipated turnover rates, etc. of the clients should be collected in order to develop more accurate estimates of space requirements -- current and future. The location of the shippers and the eventual consignees should be determined in detail so that the transportation interfaces can be determined and, more importantly, so that the optimum location for the distribution center can be determined. The optimum location is one that maximizes the economic viability of the distribution company and consequently land costs, accessability, transportation time and costs (including pickup and delivery), etc. will have an impact on the optimum location.

Figure 34 summarizes the distribution organization that was discussed earlier in this chapter. The organizational structure is similar to the organization of an air cargo terminal, particularly if it is a common-user air cargo terminal. While these organizations have similar functions, the relative importance of the individual functions vary. There could be some economies if the air cargo terminal and the distribution company were in fact one organization. The computer center, for example, is a good example where savings could be realized by combining the air cargo terminal and distribution company. Other functions, while similar, must remain independent. The distribution center warehouse can not be combined with the cargo building portion of the air cargo center -- the activities and equipment of each are entirely different. Further, the distribution company and the air cargo terminal will both be large organizations. Therefore, the economies realized by combining both organizations are probably small. If the optimum location of the distribution center is away from the airport, the two organizations still could be combined and realize almost all the advantages of a combined organization and combined location.

Figure 34

DISTRIBUTION COMPANY ORGANIZATION



A distribution center capable of accommodating an annual throughput of 100,000 to 150,000 tons will have about 200,000 square feet, and the costs of operating the center will range between $24 and $26 per ton (including profit) depending on the throughput. A terminal half this size will have costs between $26 and $28 per ton and a terminal with twice this size will have costs between $22 and $24 per ton.

We also recommend that the distribution company operate its own fleet of delivery vehicles to serve the Montreal region. We estimate that this truck fleet will deliver about 265,000 tons annually if the terminal has a throughput of 271,000 tons and will deliver about 120,000 tons if the total throughput is about 125,000 tons. The distribution center could reduce delivery costs at least $3.00 per ton through good route planning compared to the costs experienced by customers who are currently operating their own delivery systems.

Appendix A

U.S. NODES

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Appendix A

U.S. NODES

Table A-1 presents the 34 consolidated SMSA's used in this study and the member SMSA's of each.

Table A-1

SCHEDULE OF U.S. NODES

Code	Consolidated SMSA's	Member SMSA's
1	Wichita, Kansas	Wichita, Kansas
2	Kansas City, Mo. and Kans.	Kansas City, Mo. and Kans. St. Joseph, Mo. Topeka, Kans. Springfield, Mo.
3	Omaha, Neb.	Omaha, Neb. Lincoln, Neb.
4	Sioux City, Iowa	Sioux City, Iowa Sioux Falls, S.D.
5	Fargo, N.D.	Fargo, N.D.
6	Duluth, Minn.	Duluth, Minn.
7	Minneapolis-St. Paul, Minn.	Minneapolis-St. Paul, Minn.
8	Milwaukee, Wis.	Milwaukee, Wis. Racine, Wis. Kenosha, Wis. Madison, Wis. Green Bay, Wis.
9	Des Moines, Iowa	Des Moines, Iowa
10	Dubuque, Iowa	Dubuque, Iowa Waterloo, Iowa
11	Davenport, Iowa	Davenport, Iowa, Rock Island-Moline, Il Cedar Rapids, Iowa
12	Chicago, Ill.	Chicago, Ill. Rockford, Ill. Gary, Ind. South Bend, Ind.
13	Springfield, Ill.	Springfield, Ill. Peoria, Ill. Bloomington, Ill. Champaign-Urbana, Ill. Decatur, Ill.
14	St. Louis, Mo.	St. Louis, Mo.

Table A-1, continued

Code	Consolidated SMSA's	Member SMSA's
15	Evansville, Ind.	Evansville, Ind.
16	Louisville, Ky.	Louisville, Ky. Lexington, Ky.
17	Charleston, W.V.	Charleston, W.V. Huntington, W.V. and Ohio
18	Indianapolis, Ind.	Indianapolis, Ind. Terre Haute, Ind. Lafayette, Ind. Anderson, Ind. Muncie, Ind.
19	Toledo, Ohio	Toledo, Ohio Ft. Wayne, Ind. Lima, Ohio
20	Detroit, Mich.	Detroit, Mich. Ann Arbor, Mich. Flint, Mich. Jackson, Mich. Saginaw, Mich. Bay City, Mich.
21	Grand Rapids, Mich.	Grand Rapids, Mich. Kalamazoo, Mich. Muskegon, Mich. Lansing, Mich.
22	Cleveland, Ohio	Cleveland, Ohio Lorain, Ohio Youngstown, Ohio Canton, Ohio Akron, Ohio Mansfield, Ohio
23	Cincinnati, Ohio	Cincinnati, Ohio Hamilton, Ohio Dayton, Ohio Springfield, Ohio Columbus, Ohio
24	Erie, Pa.	Erie, Pa.

Table A-1, continued

Code	Consolidated SMSA's	Member SMSA's
25	Pittsburgh, Pa.	Pittsburgh, Pa. Wheeling, W.V. Altoona, Pa. Steubenville, Ohio Johnstown, Pa.
26	Buffalo, New York	Buffalo, New York Rochester, New York
27	Syracuse, New York	Syracuse, New York Utica-Rome, New York
28	Albany, New York	Albany, New York Pittsfield, Mass.
29	Scranton, Pa.	Scranton, Pa. Wilkes-Barre, Pa. Binghamton, New York
30	Baltimore, Md.	Baltimore, Md. Washington, D.C. Harrisburg, Pa. York, Pa.
31	Philadelphia, Pa.	Philadelphia, Pa. Trenton, N.J. Wilmington, Del. Lancaster, Pa. Reading, Pa. Vineland, N.J. Atlantic City, N.J.
32	New York, New York	New York, New York Newark, N.J. Allentown, Pa. Paterson, N.J. Stamford, Conn. New Haven, Conn. Norwalk, Conn. Waterbury, Conn. New London, Conn. Bridgeport, Conn. Jersey City, N.J.

Table A-1, continued

Code	Consolidated SMSA's	Member SMSA's
33	Hartford, Conn.	Hartford, Conn. Springfield, Mass. Meriden, Conn.
34	Boston, Mass.	Boston, Mass. Worcester, Mass. Fitchburg, Mass. Manchester, N.H. Lawrence, Mass. Providence, R.I. Fall River, Mass. Brockton, Mass. New Bedford, Mass. Lowell, Mass.

Source: Statistical Abstract of the United States, 1970.

Appendix B

CARGO DATA BASE

Appendix B

CARGO DATA BASE

This appendix describes in detail the sources and procedures used to develop the cargo data base.

The basic source for tonnage moving between Canada and Europe are various reports published by DBS. Unfortunately no single DBS report presents the import/export data in the manner we required nor are the reports consistent in the trade definitions. The 1969 issue of Imports by Commodity presents the imports by commodity, by value for each originating European country but presents no breakdown by mode, contains tonnage data only for a few selected commodities, and makes no distinction between imports destined for Canadian points and imports destined for points beyond Canada. The 1969 issue of Exports by Mode of Transport presents exports by commodity, by value and by mode for each European country of destination. This report distinguishes between domestic exports and re-exports but presents tonnage data only for a few selected commodities. The Shipping Report - Part I contains import and export tonnage moving via water to and from the European country where the cargo is loaded or discharged (not the country of origin or destination). World Air Transport Statistics, published by IATA, presents the total air cargo moving between Canada and European countries but does not give a breakdown by country or even by direction.

Since the above approach did not yield satisfactory results, we used the data presented in the Shipping Report - Part I to estimate the surface cargo movement between Canada and Europe. This report presents cargo tonnage data by commodity, by country of loading or discharge. Therefore, the surface movements to Austria and Switzerland are included in the statistics for one of the coastal European countries. We assumed the Austrian and Switzerland tonnage is included (for the most part) in the statistics for the Netherlands, Belgium, France and Italy. We assumed the tonnage to and from Austria, Switzerland, France, Belgium, Italy and the Netherlands is proportional to the value as reported in Imports by Commodity and Exports by Mode of Transport and adjusted the tonnages as reported in the Shipping Report - Part I for the latter four countries accordingly.

We used Airport Activity Statistics published by DBS to determine the ratio of imports to exports of air cargo and applied this ratio to the total North Atlantic tonnage as reported by IATA. The air cargo tonnage was then allocated to the various European countries using the same ratio of surface to air as experienced by U.S. imports and exports. The results of this allocation were then proportionally adjusted so that the total air cargo tonnage agreed with the tonnage as reported by IATA. Since we could not derive the distribution of tonnage by value, we assumed the Canadian distribution of tonnage by value would be the same as the U. S. distribution for all Canada/Europe movements except the air movement to Europe. The Exports by Mode of Transport reports tonnage data for a portion of the commodities. The average value for this portion, amounting to 4,000 short tons, was $1.60 per pound. The value for the remaining tonnage was then estimated to be $8.98 per pound. Since the value of the 1969 air cargo is not important in forecasting the cargo that will be moved by air, we used this bimodal distribution in the summary tables appearing later in this report.

The 1969 tonnage between Canada and the U.S. and between the U.S. and Europe are presented in U.S. General Imports, FT 155 and U.S. Exports, FT 455, both published by the Bureau of the Census. These reports contain cargo movements by commodity, by mode and by country of origin or destination. The reports also contain data on the value of the cargo so that we could determine the distribution by value.

The European and transborder cargoes were allocated to the CMA's and SMSA's on the basis of population in the case of imports and some measure of production activity of the individual CMA's and SMSA's in the case of exports. The Canadian exports were allocated on the basis of value added whereas the U.S. exports were allocated on the basis of the value of export shipments. The sources for the value data were Canadian Yearbook, published by the DBS and the Survey of the Origin of U.S. Exports, 1969 published by the U.S. Department of Commerce.

Reliable data on Canadian domestic air cargo movements on a point-to-point basis are not readily available. Airport Activity Statistics* presents the domestic tonnage enplaned and deplaned at each of Canada's

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* Published annually by DBS.

25 major airports. A total of 109,000 short tons were enplaned at these airports in 1970 and 104,000 short tons were deplaned. The imbalance indicates the remaining airports in Canada are net importers of domestic air cargo. Unfortunately, the statistics reported for any given airport include the tonnage originating or terminating in the airport area, domestic cargo being transshipped through the airport and international cargo being transshipped through the airport. An example of this latter type of movement would be cargo moving from Europe to Winnipeg and being transshipped on another aircraft at Montreal. The movement between Montreal and Winnipeg is classified as domestic and the loading in Montreal and unloading in Winnipeg are included in the domestic statistics.

The Traffic - Digest of Statistics No. 159* states that a total of 67,000 short tons moved in Canadian domestic service in 1970. Unfortunately the report does not have origin/destination data. The difference in the domestic tonnage reported in the two documents implies that about 40,000 short tons of the about 107,000 domestic short tons handled by the 25 major airports are actually double-handled domestic and international transshipments. Assuming that half of the transshipments are domestic and half are international shipments, and assuming the same ratios apply to Montreal, about 60 per cent of the air cargo tonnage originating or terminating in the Montreal/Ottawa area is domestic air cargo, 20 per cent is domestic transshipments and 20 per cent is international transshipments.

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* Published annually by ICAO.

We have a rough estimate of the Canadian domestic rail movements from Waybill Analysis, Carload All-Rail Traffic, CTC, 1968 and an estimate of the domestic truck movement from Road Transport Service Bulletin, DBS. We assumed the proportion of domestic surface tonnage handled in the Montreal-Ottawa area would be equal to the proportion of the domestic air cargo handled in the Montreal-Ottawa area. Since no data on the value of the cargo were available, we assume that the distribution of the surface and air cargo value would be the same as the weighted average distribution of the total northbound and southbound transborder traffic.

Appendix C

TOTAL MARKET FORECAST

Appendix C

TOTAL MARKET FORECAST

Figures C-1 through C-7 summarize the forecasts of the total market for the services analyzed with the exception of the Canadian exports to Europe. The summary figure for this service is presented in the main body of the report. The data shown in the figures for 1969 and earlier represent the actual growth of air cargo in recent years including, obviously, the growth due to stealing cargo from surface modes. The bottom lines for the years after 1969 represent the growth in air cargo assuming the air carriers do not "steal" additional cargo from surface carriers. The remaining lines represent the growth of the cargo moving by air in 1969 plus all surface cargo with a value greater than the specified value.

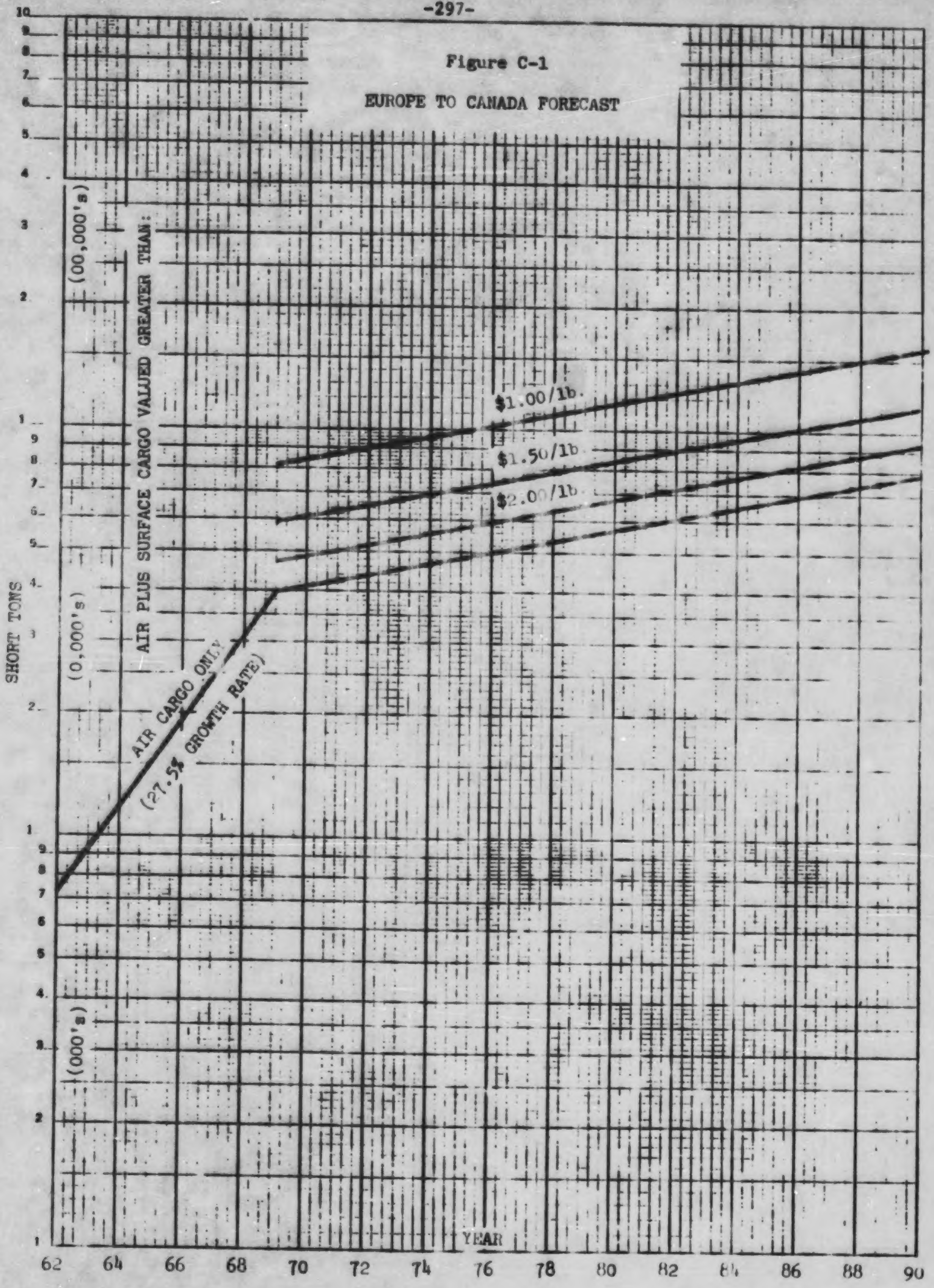
Tables C-1 through C-24 present the matrices of the cargo moving point-to-point for all services except for Canadian domestic for 1969, 1975, 1980 and 1985. The CMA, SMSA and country numbers appearing in the tables refer to the code numbers appearing in Tables 1 through 3 in the main body of the report. The 1969 tables represent 1969 air tonnage only. The remaining tables represent the forecasts of air tonnage plus all surface cargo valued at more than $1.00 per pound. Table C-25 presents the scaling factors for determining the forecast for any other penetration into surface cargo.

The "Grand Total" row in the tables for all services originating or terminating in the U.S. reflects the total cargo movement to and from the U.S. Since the "Consolidated" 34 SMSA's detailed in these tables are not all-inclusive, the sum of the individual SMSA's will be less than the value shown in the total row.

Table C-26 presents the forecast of the Canadian domestic cargo moving into and out of the Montreal area. Once again, the air tonnage shown in this table reflects the double handling due to transshipping air cargo at Montreal and Ottawa airports.

Figure C-1

EUROPE TO CANADA FORECAST



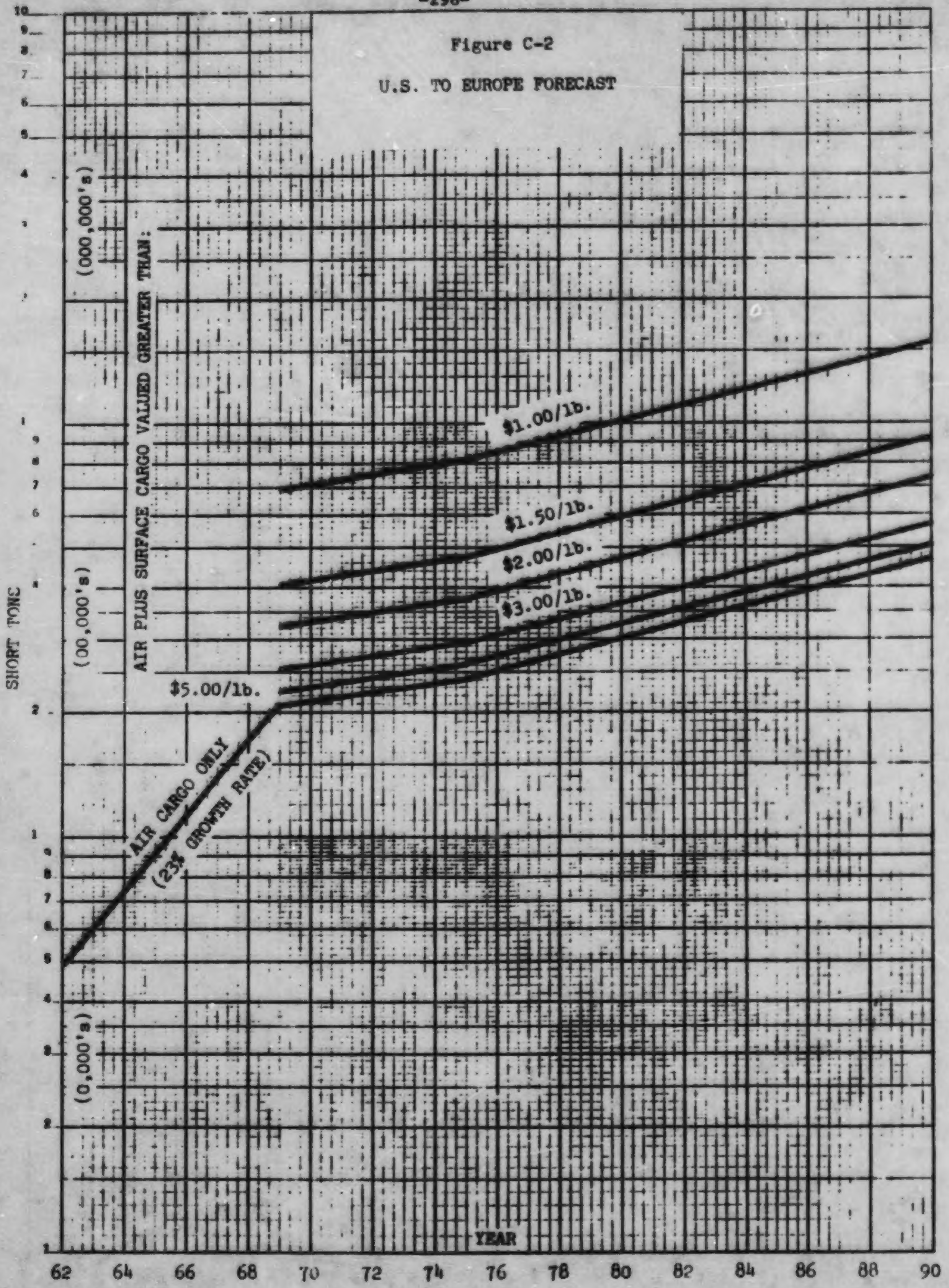
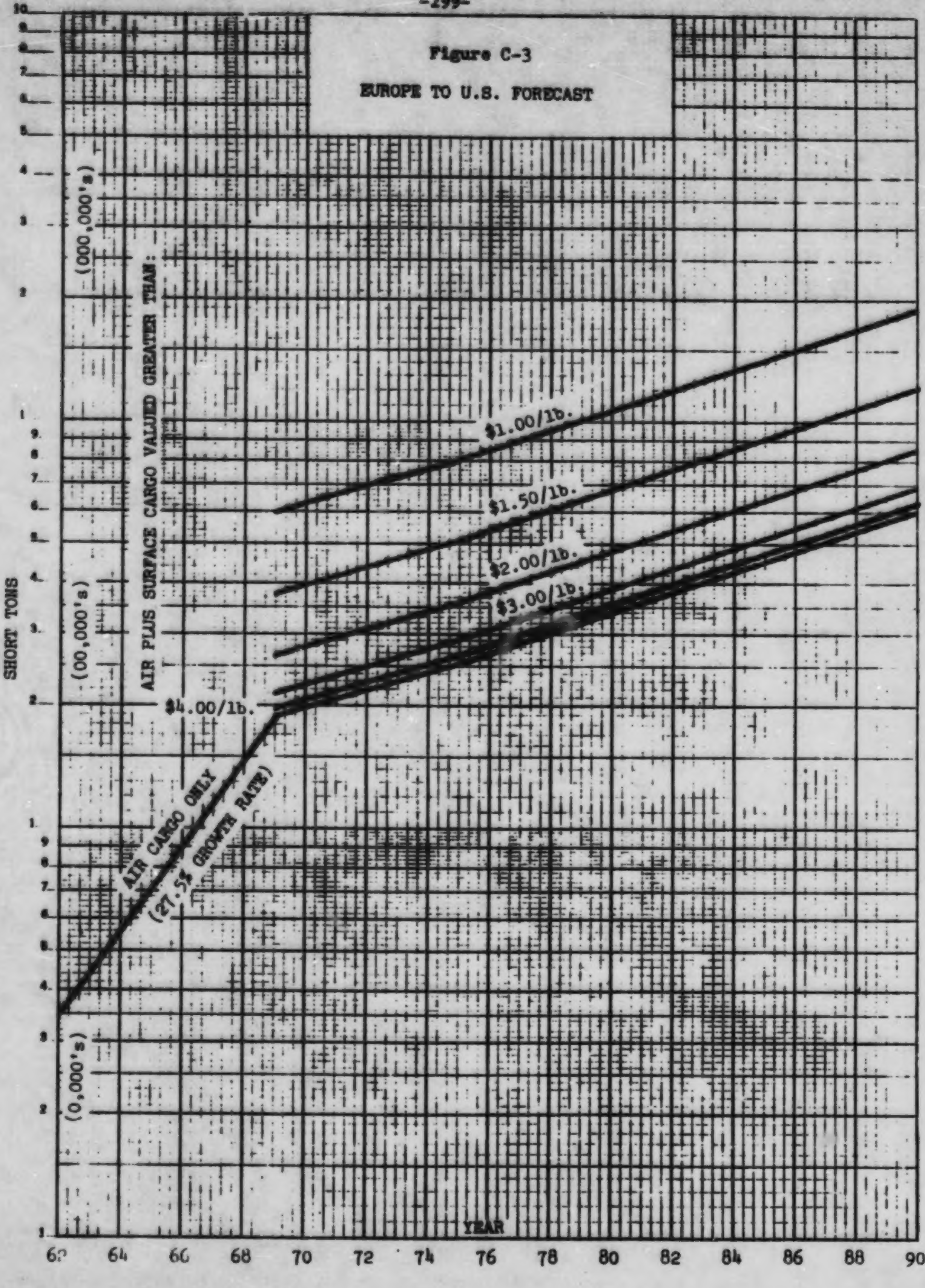


Figure C-2

U.S. TO EUROPE FORECAST

Figure C-3

EUROPE TO U.S. FORECAST



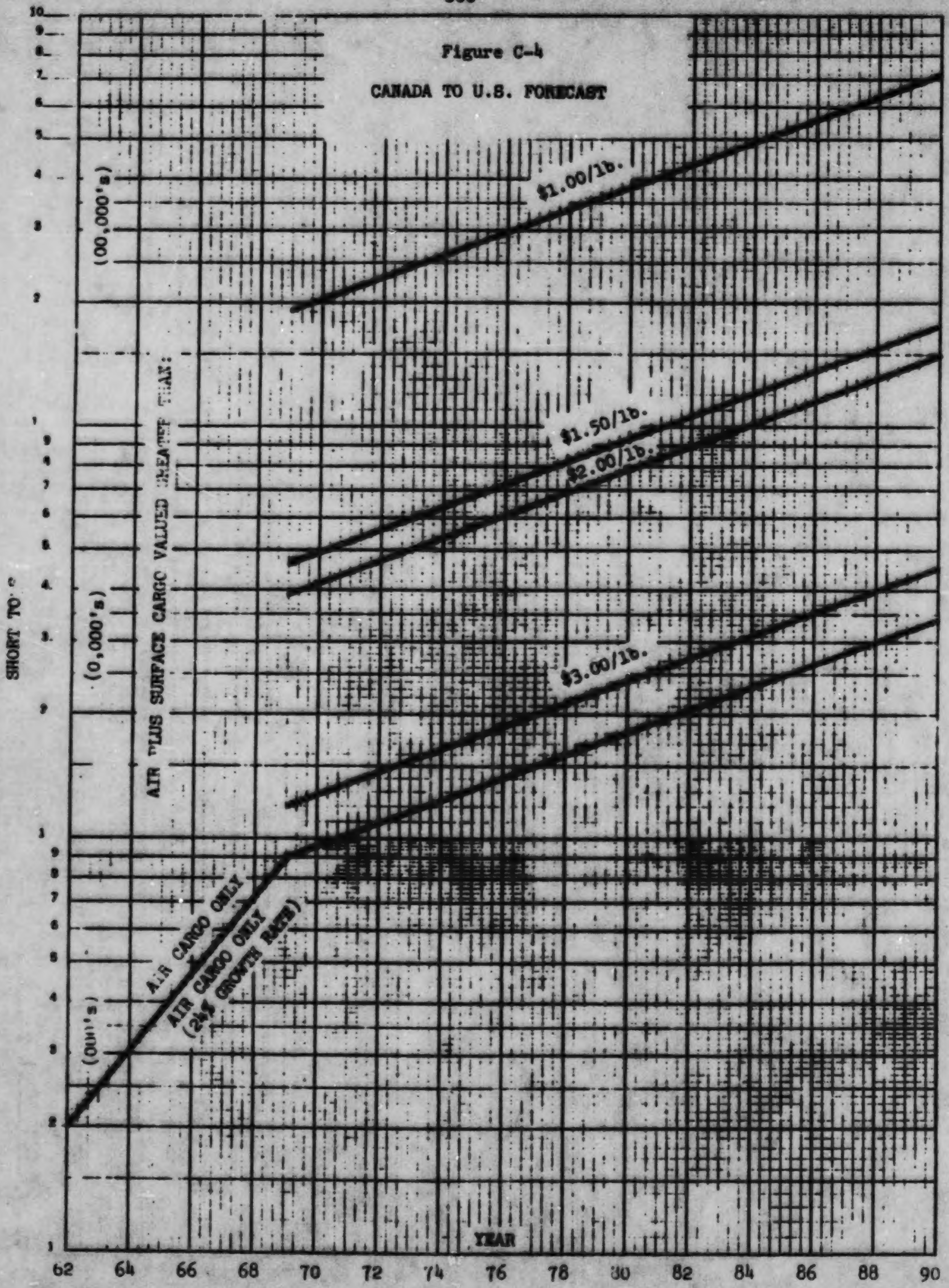
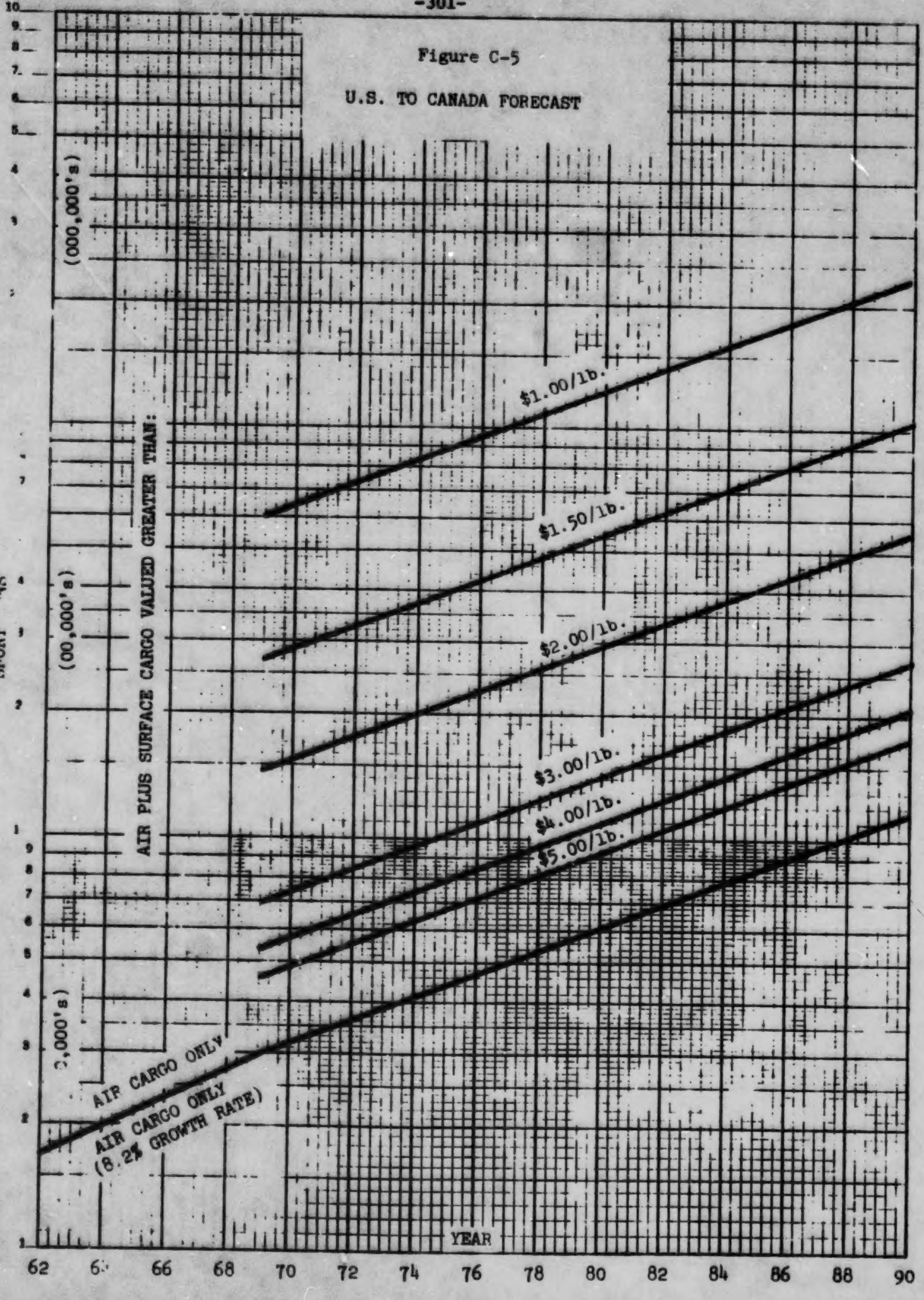


Figure C-4

CANADA TO U.S. FORECAST

Figure C-5

U.S. TO CANADA FORECAST



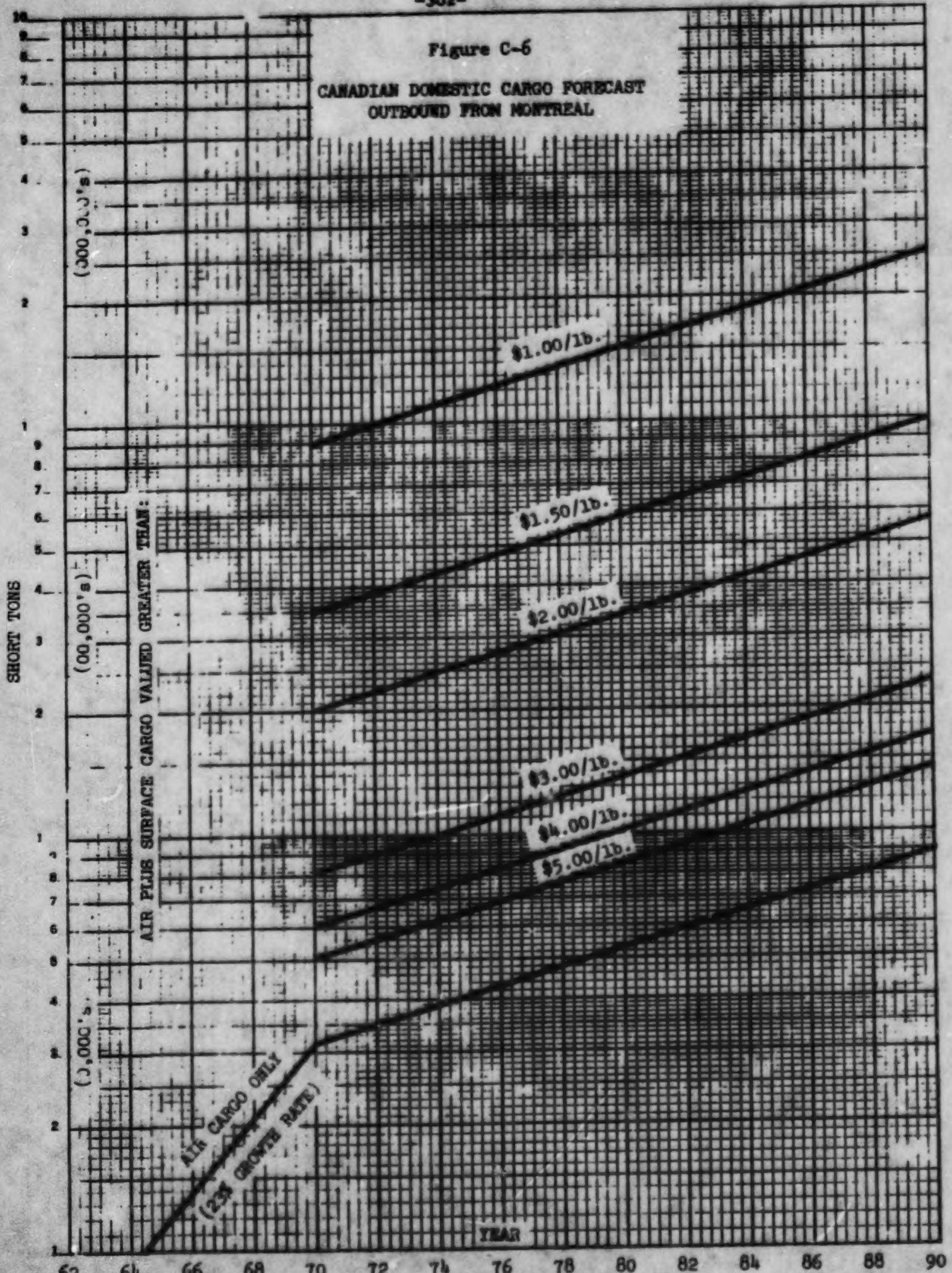


Figure C-6

CANADIAN DOMESTIC CARGO FORECAST
OUTBOUND FROM MONTREAL

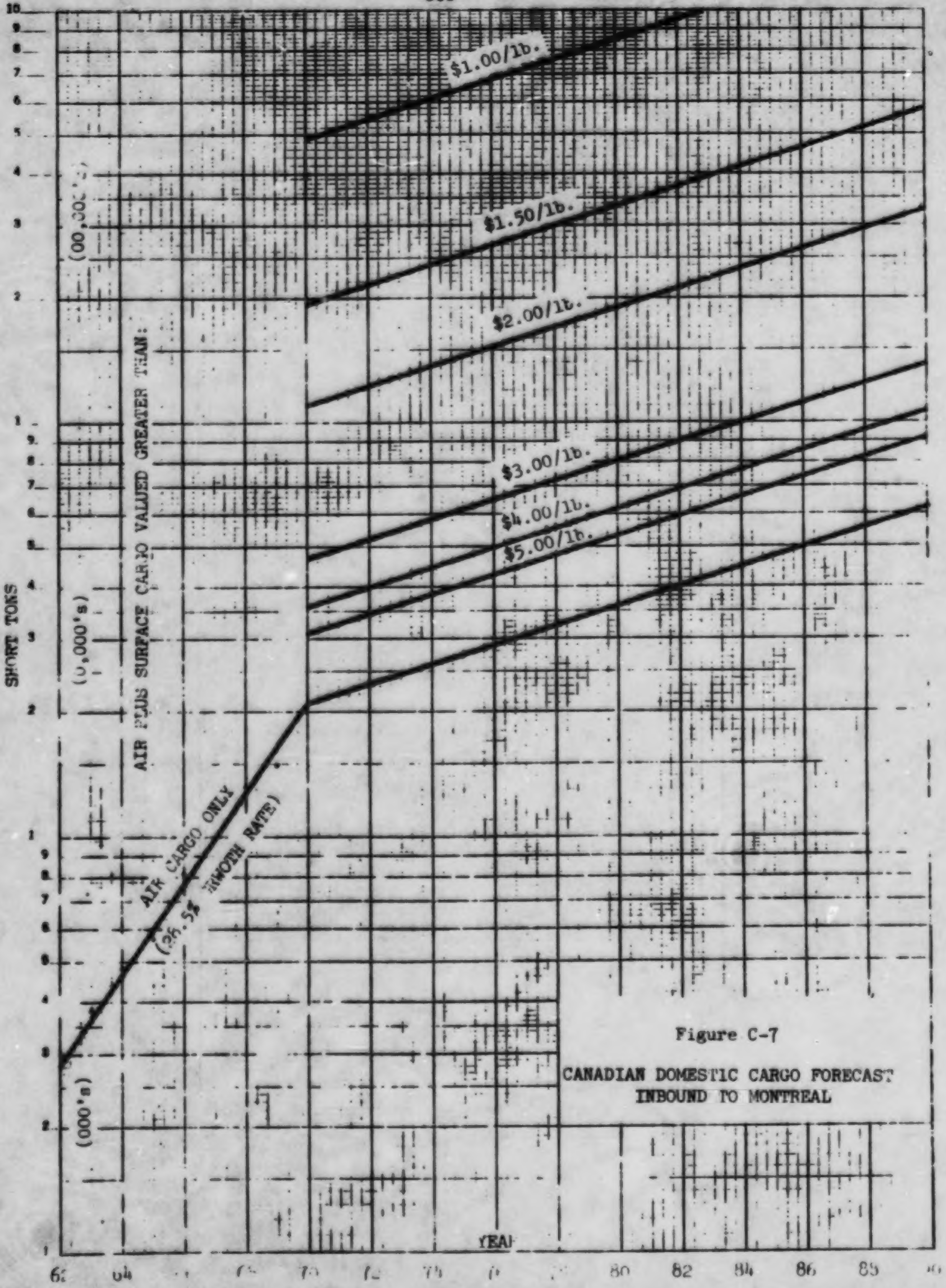


Figure C-7

CANADIAN DOMESTIC CARGO FORECAST
INBOUND TO MONTREAL

Table C-1

1969 CANADA TO EUROPE TONNAGE
AIR CARGO ONLY
(Short Tons)

CMA	Country 1	2	3	4	5	6	7	8	9	10	11
1	0	3	0	0	1	3	4	0	0	0	2
2	0	1	0	0	0	1	1	0	0	0	0
3	1	9	0	0	2	7	12	0	0	1	6
4	1	8	0	0	1	7	11	0	0	1	6
5	16	173	0	8	31	141	233	5	0	24	126
6	1	14	0	1	3	11	19	0	0	2	10
7	5	58	0	3	11	47	78	2	0	8	42
8	2	24	0	1	4	20	33	1	0	3	18
9	2	17	0	1	3	14	23	1	0	2	12
10	1	12	0	1	2	10	16	0	0	2	9
11	19	204	0	9	37	167	275	6	0	28	148
12	3	38	0	2	7	31	52	1	0	5	28
13	1	16	0	1	3	13	22	0	0	2	12
14	0	3	0	0	1	3	4	0	0	0	2
15	0	3	0	0	1	3	4	0	0	0	2
16	1	10	0	0	2	8	13	0	0	1	7
17	1	13	0	1	2	11	18	0	0	2	9
18	5	58	0	3	11	48	79	2	0	8	42
19	0	5	0	0	1	4	7	0	0	1	4
Grand Total	60	660	0	30	120	540	890	20	0	90	480

Table C-1, continued

CMA	Country 12	13	14	15	16	17	18	19	20	21	Total
1	0	6	0	0	0	0	2	0	45	0	68
2	0	1	0	0	0	0	0	0	9	0	13
3	0	17	0	0	1	1	5	0	122	0	186
4	0	15	0	0	1	1	5	0	112	0	169
5	0	322	8	0	13	21	102	3	2,375	0	3,583
6	0	26	1	0	1	2	8	0	192	0	290
7	0	108	3	0	4	7	34	1	795	0	1,199
8	0	45	1	0	2	3	14	0	335	0	504
9	0	31	1	0	1	2	10	0	230	0	346
10	0	22	1	0	1	1	7	0	165	0	248
11	0	380	9	0	15	25	120	3	2,805	0	4,233
12	0	71	2	0	3	5	23	1	526	0	794
13	0	30	1	0	1	2	10	0	222	0	335
14	0	6	0	0	0	0	2	0	42	0	65
15	0	6	0	0	0	0	2	0	43	0	65
16	0	18	0	0	1	1	6	0	131	0	198
17	0	24	1	0	1	2	8	0	179	0	270
18	0	109	3	0	4	7	35	1	804	0	1,212
19	0	9	0	0	0	1	3	0	67	0	101
Grand Total	0	1,230	30	0	50	80	390	10	9,200	0	13,880

Table C-2

1975 CANADA TO EUROPE FORECAST
AIR PLUS SURFACE CARGO VALUED GREATER THAN $1.00 PER POUND
(Short Tons)

CMA	Country 1	2	3	4	5	6	7	8	9	10	11
1	5	83	0	3	7	37	110	3	0	5	118
2	1	21	0	1	2	10	27	1	0	1	29
3	13	212	0	7	17	95	278	7	0	12	301
4	13	220	0	8	17	98	287	7	0	12	312
5	271	4,574	0	157	352	2,045	5,996	152	0	248	6,507
6	22	371	0	13	28	166	486	13	0	21	528
7	95	1,609	0	55	124	720	2,109	54	0	87	2,289
8	40	677	0	23	52	302	887	23	0	37	962
9	27	465	0	16	36	208	610	16	0	25	662
10	20	332	0	11	25	149	436	11	0	18	473
11	335	5,678	0	195	437	2,538	7,444	188	0	308	8,079
12	63	1,065	0	37	82	476	1,396	36	0	58	1,515
13	24	414	0	14	32	185	542	14	0	22	588
14	5	78	0	3	6	35	103	3	0	4	111
15	5	79	0	3	6	35	105	3	0	4	113
16	16	271	0	9	21	121	355	9	0	15	385
17	22	369	0	13	28	164	483	12	0	20	524
18	105	1,766	0	61	136	789	2,314	60	0	96	2,512
19	9	147	0	5	12	66	193	5	0	8	209
Grand Total	1,090	18,430	0	620	1,420	8,240	24,160	610	0	1,000	26,220

Table C-2

CMA	Country 12	13	14	15	16	17	18	19	20	21	Total
1	0	302	7	0	26	5	12	5	449	0	1,175
2	0	75	2	0	7	1	3	1	112	0	294
3	0	768	18	0	66	12	31	13	1,141	0	2,988
4	0	796	19	0	68	13	32	14	1,183	0	3,099
5	0	16,581	389	0	1,430	255	670	276	24,645	0	64,544
6	0	1,344	31	0	116	21	55	22	1,999	0	5,234
7	0	5,834	137	0	503	90	236	97	8,670	0	22,707
8	0	2,452	58	0	211	38	99	41	3,645	0	9,546
9	0	1,687	40	0	146	26	68	28	3,506	0	6,564
10	0	1,207	28	0	104	19	49	21	1,793	0	4,697
11	0	20,585	484	0	1,775	318	832	342	30,595	0	80,131
12	0	3,860	91	0	332	60	156	65	5,738	0	15,027
13	0	1,498	35	0	129	23	61	24	2,226	0	5,832
14	0	285	7	0	24	4	12	5	423	0	1,108
15	0	288	7	0	24	5	12	5	428	0	1,123
16	0	981	23	0	84	15	40	17	1,458	0	3,818
17	0	1,336	31	0	115	21	54	22	1,985	0	5,198
18	0	6,400	151	0	551	99	259	107	9,512	0	24,913
19	0	532	13	0	46	8	22	9	791	0	2,072
Grand Total	0	66,810	1,570	0	5,760	1,030	2,700	1,110	99,300	0	260,070

Table C-4

1985 CANADA TO EUROPE FORECAST
AIR PLUS SURFACE CARGO VALUED GREATER THAN $1.00 PER POUND
(Short Tons)

CMA	Country 1	2	3	4	5	6	7	8	9	10	11
1	7	111	0	4	9	50	146	4	0	6	158
2	3	42	0	2	3	19	56	1	0	2	60
3	15	253	0	9	19	113	332	9	0	13	359
4	19	326	0	11	25	146	427	11	0	17	463
5	386	6,564	0	222	502	2,940	8,602	218	0	354	9,335
6	32	533	0	18	41	239	698	17	0	29	757
7	148	2,508	0	85	192	1,123	3,287	83	0	135	3,568
8	62	1,054	0	35	81	473	1,382	35	0	57	1,500
9	43	726	0	25	56	325	950	24	0	39	1,031
10	31	519	0	17	39	232	680	17	0	28	738
11	521	8,853	0	300	678	3,964	11,600	293	0	477	12,589
12	98	1,660	0	57	127	744	2,175	55	0	89	2,361
13	33	560	0	19	43	251	734	18	0	31	797
14	6	104	0	4	8	46	136	4	0	6	148
15	6	105	0	4	8	47	137	4	0	6	150
16	26	434	0	14	34	195	568	14	0	23	617
17	35	590	0	20	45	265	774	19	0	32	840
18	186	3,155	0	106	242	1,413	4,135	104	0	171	4,488
19	15	263	0	9	20	118	344	9	0	14	373
Grand Total	1,670	28,360	0	960	2,170	12,700	37,160	940	0	1,530	40,330

Table C-4, continued

CMA	Country 12	13	14	15	16	17	18	19	20	21	Total
1	0	403	10	0	35	6	16	7	598	0	1,567
2	0	154	4	0	13	2	7	3	229	0	601
3	0	916	21	0	79	14	37	15	1,362	0	3,568
4	0	1,179	28	0	102	18	48	19	1,752	0	4,590
5	0	23,788	558	0	2,051	368	965	396	35,344	0	92,593
6	0	1,929	45	0	167	30	79	32	2,867	0	7,511
7	0	9,091	213	0	784	141	369	151	13,506	0	35,384
8	0	3,822	89	0	330	59	155	63	5,678	0	14,875
9	0	2,627	61	0	226	40	106	44	3,904	0	10,228
10	0	1,881	44	0	162	29	77	32	2,794	0	7,319
11	0	32,080	752	0	2,765	497	1,302	534	47,665	0	124,870
12	0	6,016	141	0	519	93	244	100	8,939	0	23,417
13	0	2,029	48	0	175	32	82	34	3,015	0	7,899
14	0	376	9	0	33	6	15	7	558	0	1,461
15	0	381	9	0	33	6	15	7	566	0	1,481
16	0	1,572	36	0	135	24	64	26	2,336	0	6,119
17	0	2,140	50	0	184	34	87	35	3,179	0	8,330
18	0	11,436	268	0	986	177	464	191	16,992	0	44,514
19	0	951	22	0	82	14	38	16	1,413	0	3,703
Grand Total	0	102,770	2,410	0	8,860	1,590	4,170	1,710	152,700	0	400,030

Table C-5

1969 EUROPE TO CANADA TONNAGE
AIR CARGO ONLY
(Short Tons)

CMA	Country 1	2	3	4	5	6	7	8	9	10	11
1	36	38	0	21	0	27	112	4	0	10	71
2	8	8	0	5	0	6	24	1	0	2	15
3	53	56	0	32	1	40	166	6	0	14	106
4	44	46	0	26	1	33	136	5	0	12	87
5	358	378	0	212	5	271	1,116	41	0	95	712
6	60	64	0	36	1	46	188	7	0	16	120
7	63	66	0	37	1	47	196	7	0	17	125
8	27	28	0	16	0	20	84	3	0	7	53
9	29	31	0	17	0	22	94	3	0	8	58
10	69	73	0	41	1	52	215	8	0	18	137
11	304	320	0	180	4	229	947	35	0	81	604
12	29	31	0	17	0	22	91	3	0	8	58
13	68	72	0	41	1	52	213	8	0	18	136
14	35	37	0	21	0	26	109	4	0	9	69
15	32	34	0	19	0	24	100	4	0	9	64
16	50	53	0	30	1	38	157	6	0	13	100
17	59	62	0	35	1	44	183	7	0	16	117
18	122	129	0	72	2	92	380	14	0	32	242
19	23	24	0	13	0	17	71	3	0	6	45
Grand Total	1,470	1,550	0	870	20	1,110	4,580	170	0	390	2,920

Table C-5, continued

CMA	Country 12	13	14	15	16	17	18	19	20	21	Total
1	0	11	0	6	20	18	237	0	369	4	985
2	0	2	0	1	4	4	51	0	79	1	211
3	0	16	1	9	29	27	351	0	548	6	1,462
4	0	13	1	8	24	22	288	0	449	5	1,197
5	0	107	5	63	195	180	2,357	0	3,677	39	9,811
6	0	18	1	11	33	30	397	0	620	7	1,653
7	0	19	1	11	34	32	413	0	645	7	1,720
8	0	8	0	5	15	14	177	0	276	3	736
9	0	9	0	5	16	15	193	0	302	3	805
10	0	21	1	12	38	35	455	0	709	8	1,893
11	0	91	4	54	165	153	1,999	0	3,119	33	8,323
12	0	9	0	5	16	15	192	0	300	3	801
13	0	20	1	12	37	34	451	0	703	7	1,876
14	0	10	0	6	19	18	230	0	358	4	956
15	0	10	0	6	18	16	212	0	330	4	881
16	0	15	1	9	27	25	332	0	518	5	1,381
17	0	18	1	10	32	30	387	0	603	6	1,609
18	0	36	2	22	66	61	802	0	1,252	13	3,339
19	0	7	0	4	12	11	149	0	233	2	621
Grand Total	0	440	20	260	800	740	9,670	0	15,090	160	40,260

Table C-6

1975 EUROPE TO CANADA FORECAST
AIR PLUS SURFACE CARGO VALUED GREATER THAN $1.00 PER POUND
(Short Tons)

CMA	Country 1	2	3	4	5	6	7	8	9	10	11
1	55	261	0	33	6	75	266	46	0	17	207
2	11	53	0	7	1	15	54	9	0	3	42
3	77	365	0	47	9	105	372	64	0	24	288
4	64	301	0	38	7	87	306	53	0	20	238
5	557	2,631	0	335	63	760	2,681	463	0	171	2,082
6	93	441	0	56	11	127	449	78	0	29	349
7	99	467	0	60	11	135	476	82	0	30	370
8	45	214	0	27	5	62	218	38	0	14	169
9	47	222	0	28	5	64	226	39	0	14	176
10	110	519	0	66	12	150	529	91	0	34	410
11	496	2,340	0	298	56	676	2,385	412	0	152	1,852
12	44	210	0	27	5	61	214	37	0	14	166
13	101	477	0	61	11	138	486	84	0	31	377
14	49	232	0	30	6	67	237	41	0	15	185
15	48	226	0	29	5	65	231	40	0	15	180
16	81	384	0	49	9	111	392	68	0	25	304
17	92	435	0	55	10	126	443	77	0	28	344
18	207	977	0	124	23	282	996	172	0	64	773
19	37	175	0	22	4	51	179	31	0	11	139
Grand Total	2,310	10,930	0	1,390	260	3,150	11,140	1,920	0	710	8,650

Table C-6, continued

CMA	Country										
	12	13	14	15	16	17	18	19	20	21	Total
1	0	77	12	21	60	47	302	10	862	15	2,373
2	0	16	3	4	12	10	62	2	176	3	482
3	0	107	17	30	84	66	422	14	1,205	20	3,316
4	0	89	14	25	69	54	348	12	994	17	2,735
5	0	774	125	215	603	473	3,045	101	8,688	147	23,905
6	0	130	21	36	101	79	511	17	1,457	25	4,007
7	0	138	22	38	107	84	541	18	1,544	26	4,246
8	0	63	10	17	49	38	246	8	704	12	1,938
9	0	65	11	18	51	40	257	9	733	12	2,017
10	0	153	25	42	119	93	600	20	1,712	29	4,712
11	0	689	112	191	536	421	2,708	90	7,729	131	21,263
12	0	62	10	17	48	38	242	8	692	12	1,905
13	0	140	23	39	109	86	552	18	1,575	27	4,335
14	0	69	11	19	53	42	269	9	769	13	2,116
15	0	67	11	18	52	41	262	9	748	13	2,059
16	0	113	18	31	88	69	445	15	1,270	22	3,495
17	0	128	21	35	100	78	503	17	1,436	24	3,951
18	0	287	47	80	224	176	1,130	38	3,226	55	8,874
19	0	52	8	14	40	31	203	7	578	10	1,590
Grand Total	0	3,210	520	890	2,500	1,960	12,650	420	36,100	610	99,320

Table C-7

1980 EUROPE TO CANADA FORECAST
AIR PLUS SURFACE CARGO VALUED GREATER THAN $1.00 PER POUND
(Short Tons)

CMA	Country										
	1	2	3	4	5	6	7	8	9	10	11
1	64	299	0	38	7	87	305	53	0	20	237
2	12	59	0	7	1	17	60	10	0	4	46
3	84	398	0	51	10	114	406	70	0	26	314
4	70	330	0	42	8	95	336	58	0	22	261
5	646	3,045	0	387	74	878	3,102	538	0	199	2,407
6	108	508	0	65	12	146	518	90	0	33	402
7	116	547	0	70	13	157	557	97	0	36	433
8	56	264	0	33	6	76	268	47	0	17	208
9	56	264	0	33	6	76	268	47	0	17	208
10	130	611	0	78	15	176	622	108	0	40	483
11	598	2,817	0	359	69	812	2,870	498	0	184	2,227
12	50	238	0	30	6	69	243	42	0	16	188
13	112	528	0	67	13	152	538	93	0	34	418
14	53	249	0	32	6	72	254	44	0	16	197
15	54	254	0	32	6	73	259	45	0	17	200
16	97	459	0	58	11	132	468	81	0	30	363
17	107	506	0	64	12	146	516	90	0	33	401
18	258	1,215	0	155	30	350	1,238	215	0	79	961
19	45	211	0	27	5	61	215	37	0	14	167
Grand Total	2,700	12,800	0	1,620	310	3,690	13,040	2,250	0	830	10,120

Table C-7, continued

CMA	Country 12	13	14	15	16	17	18	19	20	21	Total
1	0	88	15	25	69	54	346	12	988	17	2,721
2	0	17	3	5	13	11	68	2	193	3	530
3	0	117	20	33	91	72	460	15	1,314	23	3,615
4	0	97	16	27	76	60	382	13	1,090	19	2,999
5	0	894	151	251	697	550	3,520	117	10,051	172	27,662
6	0	149	25	42	116	92	588	20	1,678	29	4,617
7	0	160	27	45	125	99	632	21	1,805	31	4,967
8	0	78	13	22	61	48	304	10	869	15	2,392
9	0	78	13	22	61	48	304	10	868	15	2,391
10	0	179	30	50	140	110	706	24	2,017	35	5,551
11	0	827	139	232	645	509	3,258	108	9,302	159	25,599
12	0	70	12	20	55	43	274	9	785	13	2,160
13	0	155	26	44	121	95	612	20	1,745	30	4,802
14	0	73	12	21	57	45	287	10	821	14	2,260
15	0	75	13	21	58	46	293	10	836	14	2,302
16	0	135	23	38	105	83	531	18	1,516	26	4,173
17	0	149	25	42	116	92	586	19	1,672	29	4,601
18	0	357	60	100	278	220	1,405	47	4,011	69	11,040
19	0	62	10	17	49	38	245	8	697	12	1,919
Grand Total	0	3,760	630	1,050	2,930	2,300	14,800	490	42,260	720	116,300

Table C-8

1985 EUROPE TO CANADA FORECAST
AIR PLUS SURFACE CARGO VALUED GREATER THAN $1.00 PER POUND
(Short Tons)

CMA	Country										
	1	2	3	4	5	6	7	8	9	10	11
1	72	342	0	44	8	99	348	60	0	23	271
2	14	64	0	8	2	19	67	11	0	4	50
3	92	433	0	55	11	125	440	76	0	29	342
4	76	361	0	46	9	104	368	63	0	24	286
5	744	3,517	0	446	85	1,015	3,580	618	0	232	2,782
6	124	584	0	75	14	168	595	103	0	39	462
7	135	638	0	82	15	184	649	112	0	42	505
8	68	325	0	42	8	93	331	57	0	21	256
9	66	311	0	40	8	90	317	54	0	21	246
10	152	719	0	92	17	207	723	126	0	47	568
11	717	3,385	0	430	82	976	3,446	595	0	224	2,678
12	57	269	0	34	7	77	274	48	0	18	213
13	124	584	0	75	14	168	595	103	0	39	462
14	56	265	0	34	6	76	270	47	0	18	210
15	59	282	0	36	7	81	288	49	0	19	224
16	116	547	0	70	13	157	557	96	0	36	434
17	125	589	0	75	14	170	600	103	0	39	466
18	320	1,508	0	193	37	436	1,536	265	0	100	1,194
19	53	254	0	33	6	73	259	45	0	17	201
Grand Total	3,170	14,980	0	1,900	360	4,320	15,250	2,630	0	980	11,850

Table C-8, continued

CMA	Country 12	13	14	15	16	17	18	19	20	21	Total
1	0	101	17	28	78	61	397	13	1,132	19	3,115
2	0	19	3	5	15	12	74	2	211	4	581
3	0	127	21	36	99	78	501	17	1,430	25	3,934
4	0	106	18	30	83	65	419	14	1,194	20	3,284
5	0	1,033	173	289	806	631	4,071	138	11,616	199	31,963
6	0	171	29	48	134	105	676	23	1,930	33	5,311
7	0	187	31	53	146	115	738	25	2,108	36	5,800
8	0	95	16	27	74	58	375	13	1,071	18	2,948
9	0	91	15	26	71	55	360	12	1,027	18	2,828
10	0	211	35	59	164	129	831	28	2,373	41	6,529
11	0	995	167	279	775	608	3,919	132	11,183	192	30,771
12	0	79	13	22	61	48	312	11	889	15	2,446
13	0	171	29	48	134	105	676	23	1,930	33	5,310
14	0	78	13	22	60	48	307	10	876	15	2,410
15	0	83	14	23	64	50	327	11	933	16	2,569
16	0	160	27	45	126	98	633	21	1,808	31	4,976
17	0	173	29	48	135	106	681	23	1,945	33	5,351
18	0	443	74	124	345	272	1,746	59	4,984	85	13,713
19	0	75	13	21	58	46	295	10	840	14	2,312
Grand Total	0	4,400	730	1,220	3,430	2,690	17,340	580	49,480	840	136,150

Table C-9

1969 U.S. TO EUROPE TONNAGE
AIR CARGO ONLY
(Short Tons)

SMSA	Country										
	1	2	3	4	5	6	7	8	9	10	11
1	7	101	0	21	6	203	235	12	2	19	119
2	4	50	0	10	3	100	116	6	1	9	59
3	2	24	0	5	1	49	57	3	0	5	29
4	1	9	0	2	1	18	21	1	0	2	11
5	0	1	0	0	0	3	3	0	0	0	2
6	0	0	0	0	0	1	1	0	0	0	1
7	11	146	0	30	9	294	341	17	3	28	173
8	34	475	2	97	28	959	1,109	56	9	91	562
9	1	15	0	3	1	30	34	2	0	3	17
10	5	64	0	13	4	129	149	8	1	12	76
11	10	135	0	28	8	273	315	16	3	26	160
12	89	1,226	4	250	73	2,475	2,863	145	24	234	1,451
13	28	386	1	79	23	781	903	46	8	74	458
14	7	94	0	19	6	189	219	11	2	18	111
15	2	21	0	4	1	43	50	3	0	4	25
16	12	167	1	34	10	338	391	20	3	32	198
17	11	145	0	30	9	294	340	17	3	28	172
18	17	231	1	47	14	468	541	27	5	44	274
19	18	247	1	50	15	499	577	29	5	47	293
20	77	1,068	4	218	63	2,158	2,495	127	21	204	1,265
21	6	88	0	18	5	179	207	10	2	17	105
22	56	780	3	159	46	1,575	1,822	92	15	149	924
23	34	476	2	97	28	962	1,113	56	9	91	564
24	6	79	0	16	5	160	185	9	2	15	94
25	27	369	1	75	22	745	862	44	7	70	437
26	37	505	2	103	30	1,019	1,178	60	10	96	598
27	11	152	0	31	9	307	355	18	3	29	180
28	13	182	1	37	11	368	425	22	4	35	216
29	3	41	0	8	2	84	97	5	1	8	49
30	20	272	1	56	16	550	636	32	5	52	323
31	54	752	2	153	45	1,520	1,757	89	15	144	891
32	113	1,561	5	318	92	3,153	3,646	185	31	298	1,849
33	14	190	1	39	11	384	444	23	4	36	225
34	35	490	2	100	29	989	1,144	58	10	93	580
Grand Total	1,100	15,200	50	3,100	900	30,700	35,500	1,800	300	2,900	18,000

Table C-9, continued

SMSA	Country 12	13	14	15	16	17	18	19	20	21	Total
1	0	121	11	8	29	71	64	4	340	5	1,378
2	0	60	6	4	14	35	31	2	168	2	681
3	0	29	3	2	7	17	15	1	82	1	331
4	0	11	1	1	3	6	6	0	30	0	122
5	0	2	0	0	0	1	1	0	5	0	18
6	0	1	0	0	0	0	0	0	2	0	6
7	1	176	16	12	42	103	92	6	493	7	1,997
8	2	572	53	37	137	334	300	19	1,606	22	6,505
9	0	18	2	1	4	10	9	1	50	1	201
10	0	77	7	5	19	45	40	3	216	3	877
11	1	163	15	11	39	95	85	5	457	6	1,850
12	6	1,476	137	97	355	863	774	48	4,145	56	16,788
13	2	465	43	31	112	272	244	15	1,307	18	5,294
14	0	113	10	7	27	66	59	4	317	4	1,284
15	0	26	2	2	6	15	14	1	72	1	293
16	1	202	19	13	48	118	106	7	566	8	2,294
17	1	175	16	11	42	102	92	6	492	7	1,992
18	1	279	26	18	67	163	146	9	783	11	3,171
19	1	298	28	20	72	174	156	10	836	11	3,386
20	5	1,286	119	84	309	752	675	42	3,613	49	14,634
21	0	106	10	7	26	62	56	3	299	4	1,212
22	4	939	87	62	226	549	493	31	2,637	36	10,683
23	2	574	53	38	138	335	301	19	1,611	22	6,526
24	0	95	9	6	23	56	50	3	268	4	1,084
25	2	444	41	29	107	260	233	15	1,247	17	5,053
26	2	608	56	40	146	355	319	20	1,706	23	6,912
27	1	183	17	12	44	107	96	6	514	7	2,081
28	1	219	20	14	53	128	115	7	616	8	2,495
29	0	50	5	3	12	29	26	2	140	2	567
30	1	328	30	22	79	192	172	11	921	13	3,731
31	3	906	84	59	218	530	475	30	2,544	35	10,305
32	7	1,880	175	123	452	1,099	986	62	5,279	72	21,384
33	1	229	21	15	55	134	120	8	643	9	2,606
34	2	590	55	39	142	345	309	19	1,656	23	6,707
Grand Total	70	18,300	1,700	1,200	4,400	10,700	9,600	600	51,400	700	208,200

Table C-10

1975 U.S. TO EUROPE FORECAST
AIR PLUS SURFACE CARGO VALUED GREATER THAN $1.00 PER POUND
(Short Tons)

SMSA	Country 1	2	3	4	5	6	7	8	9	10	11
1	26	375	1	102	29	757	874	52	7	68	519
2	13	186	1	50	14	374	433	26	3	33	257
3	6	90	0	25	7	182	210	12	2	16	125
4	2	33	0	9	3	67	77	5	1	6	46
5	0	5	0	1	0	10	12	1	0	1	7
6	0	2	0	0	0	3	4	0	0	0	2
7	38	544	2	148	42	1,097	1,268	75	10	98	753
8	125	1,771	7	481	137	3,571	4,127	244	31	319	2,449
9	4	55	0	15	4	110	128	8	1	10	76
10	17	239	1	65	19	481	556	33	4	43	330
11	36	504	2	137	39	1,016	1,174	69	9	91	697
12	322	4,571	17	1,242	355	9,215	10,650	629	81	822	6,320
13	102	1,441	5	391	112	2,905	3,358	198	25	259	1,993
14	25	350	1	95	27	706	816	48	6	63	484
15	6	80	0	22	6	161	186	11	1	14	110
16	44	625	2	170	48	1,260	1,456	86	11	112	864
17	38	542	2	147	42	1,093	1,263	75	10	98	750
18	61	864	3	235	67	1,741	2,012	119	15	155	1,194
19	65	922	3	251	72	1,859	2,149	127	16	166	1,275
20	281	3,986	15	1,083	309	8,035	9,286	548	70	717	5,511
21	23	330	1	90	26	666	769	45	6	59	457
22	205	2,908	11	790	226	5,863	6,776	400	51	523	4,022
23	125	1,777	7	483	138	3,582	4,140	244	31	320	2,457
24	21	295	1	80	23	595	687	41	5	53	408
25	97	1,376	5	374	107	2,773	3,205	189	24	247	1,902
26	133	1,882	7	511	146	3,795	4,386	259	33	339	2,603
27	40	567	2	154	44	1,143	1,321	78	10	102	784
28	48	679	3	184	53	1,369	1,582	93	12	122	939
29	11	155	1	42	12	312	360	21	3	28	214
30	72	1,016	4	276	79	2,048	2,367	140	18	183	1,405
31	198	2,806	10	762	218	5,656	6,536	386	49	505	3,879
32	411	5,821	22	1,581	452	11,735	13,562	801	103	1,047	8,049
33	50	710	3	193	55	1,431	1,654	98	13	128	982
34	129	1,826	7	496	142	3,682	4,255	251	32	329	2,526
Grand Total	4,000	56,700	210	15,400	4,400	114,300	132,100	7,800	1,000	10,200	78,400

Table C-10, continued

SMSA	Country 12	13	14	15	16	17	18	19	20	21	Total
1	2	451	57	56	201	349	236	17	1,194	21	5,392
2	1	223	28	28	99	173	117	8	591	10	2,668
3	0	108	14	13	48	84	57	4	287	5	1,298
4	0	40	5	5	18	31	21	1	105	2	475
5	0	6	1	1	3	5	3	0	16	0	72
6	0	2	0	0	1	2	1	0	5	0	24
7	3	654	83	81	291	507	343	24	1,732	30	7,820
8	8	2,127	269	262	947	1,649	1,115	78	5,635	97	25,449
9	0	66	8	8	29	51	34	2	174	3	786
10	1	287	36	35	128	222	150	11	760	13	3,430
11	2	605	76	75	269	469	317	22	1,603	28	7,239
12	22	5,490	693	677	2,443	4,257	2,878	202	14,543	250	65,677
13	7	1,731	219	214	770	1,342	907	64	4,586	79	20,709
14	2	420	53	52	187	326	220	15	1,114	19	5,030
15	0	96	12	12	43	74	50	4	254	4	1,147
16	3	750	95	93	334	582	393	28	1,988	34	8,977
17	3	651	82	80	290	505	341	24	1,725	30	7,791
18	4	1,037	131	128	462	804	544	38	2,748	47	12,409
19	4	1,108	140	137	493	859	581	41	2,934	50	13,252
20	19	4,787	605	590	2,130	3,712	2,510	176	12,681	218	57,269
21	2	397	50	49	176	308	208	15	1,051	18	4,745
22	14	3,493	441	431	1,554	2,708	1,831	128	9,254	159	41,789
23	8	2,134	269	263	949	1,655	1,119	78	5,653	97	25,529
24	1	354	45	44	158	275	186	13	939	16	4,240
25	7	1,652	209	204	735	1,281	866	61	4,377	75	19,768
26	9	2,261	286	279	1,006	1,753	1,185	83	5,989	103	27,046
27	3	681	86	84	303	528	357	25	1,804	31	8,147
28	3	815	103	101	363	632	427	30	2,160	37	9,755
29	1	186	23	23	83	144	97	7	492	8	2,221
30	5	1,220	154	151	543	946	640	45	3,233	56	14,601
31	13	3,370	426	416	1,499	2,613	1,766	124	8,926	153	40,310
32	28	6,992	883	862	3,111	5,421	3,665	257	18,521	318	83,641
33	3	853	108	105	379	661	447	31	2,259	39	10,201
34	9	2,194	277	271	976	1,701	1,150	81	5,811	100	26,243
Grand Total	270	68,100	8,600	8,400	30,300	52,800	35,700	2,500	180,400	3,100	814,680

Table C-11

1980 U.S. TO EUROPE FORECAST
AIR PLUS SURFACE CARGO VALUED GREATER THAN $1.00 PER POUND

(Short Tons)

	Country										
SMSA	1	2	3	4	5	6	7	8	9	10	11
1	33	470	2	124	36	947	1,095	66	8	85	662
2	16	233	1	62	18	469	542	32	4	42	328
3	8	113	0	30	9	228	264	16	2	20	159
4	3	41	0	11	3	83	96	6	1	7	58
5	0	6	0	2	0	13	15	1	0	1	9
6	0	2	0	1	0	4	5	0	0	0	3
7	48	682	3	181	52	1,374	1,589	95	12	123	960
8	156	2,218	8	587	169	4,469	5,166	309	37	400	3,123
9	5	69	0	18	5	138	160	10	1	12	97
10	21	299	1	79	23	602	696	42	5	54	421
11	44	631	2	167	48	1,272	1,470	88	11	114	889
12	403	5,723	22	1,515	435	11,534	13,332	798	97	1,032	8,060
13	127	1,804	7	478	137	3,637	4,204	252	30	325	2,541
14	31	439	2	116	33	884	1,022	61	7	79	618
15	7	100	0	26	8	202	233	14	2	18	141
16	55	782	3	207	60	1,577	1,823	109	13	141	1,102
17	48	679	3	180	52	1,368	1,581	95	11	122	956
18	76	1,082	4	286	82	2,180	2,520	151	18	195	1,523
19	81	1,155	4	306	888	2,328	2,691	161	20	208	1,627
20	352	4,992	19	1,322	380	10,060	11,628	696	84	900	7,030
21	29	414	2	110	31	834	964	58	7	75	583
22	256	3,641	14	964	277	7,338	8,482	508	62	656	5,128
23	157	2,224	8	589	169	4,483	5,182	310	38	401	3,133
24	26	369	1	98	28	744	860	51	6	67	520
25	121	1,723	7	456	131	3,472	4,013	240	29	311	2,426
26	166	2,357	9	624	179	4,751	5,491	329	40	425	3,320
27	50	710	3	188	54	1,431	1,654	99	12	128	1,000
28	60	850	3	225	65	1,712	1,979	118	14	153	1,197
29	14	194	1	51	15	390	451	27	3	35	273
30	90	1,273	5	337	97	2,565	2,964	177	22	229	1,792
31	247	3,512	13	930	267	7,079	8,182	490	59	633	4,947
32	513	7,287	28	1,929	554	14,686	16,975	1,016	123	1,314	10,263
33	63	889	3	235	68	1,792	2,071	124	15	160	1,252
34	161	2,287	9	606	174	4,609	5,328	319	39	412	3,221
Grand Total	5,000	71,000	270	18,800	5,400	143,100	165,400	9,900	1,200	12,800	100,000

Table C-12

1985 U.S. TO EUROPE FORECAST
AIR PLUS SURFACE CARGO VALUED GREATER THAN $1.00 PER POUND
(Short Tons)

	Country										
SMSA	1	2	3	4	5	6	7	8	9	10	11
1	41	589	2	152	44	1,186	1,371	84	9	106	845
2	20	292	1	75	22	588	679	42	5	52	418
3	10	142	0	37	11	286	330	20	2	26	204
4	4	52	0	13	4	104	121	7	1	9	74
5	1	8	0	2	1	16	18	1	0	1	11
6	0	3	0	1	0	5	6	0	0	0	4
7	60	854	3	220	64	1,722	1,990	122	13	154	1,226
8	194	2,776	9	715	209	5,596	6,467	397	44	500	3,985
9	6	86	0	22	6	173	200	12	1	15	123
10	26	374	1	96	28	754	872	53	6	67	537
11	55	790	3	203	60	1,592	1,840	113	12	142	1,134
12	500	7,164	24	1,845	540	14,441	16,690	1,023	113	1,289	10,283
13	158	2,259	8	582	170	4,553	5,262	323	36	407	3,242
14	38	550	2	142	41	1,109	1,281	79	9	99	789
15	9	125	0	32	9	253	292	18	2	23	180
16	68	980	3	252	74	1,975	2,282	140	15	176	1,406
17	59	850	3	219	64	1,713	1,979	121	13	153	1,220
18	94	1,354	5	349	102	2,730	3,155	193	21	244	1,944
19	101	1,447	5	373	109	2,916	3,370	207	23	260	2,076
20	436	6,251	21	1,610	471	12,600	14,561	893	98	1,125	8,972
21	36	519	2	134	39	1,045	1,208	74	8	93	744
22	318	4,558	15	1,174	343	9,187	10,618	651	72	820	6,542
23	194	2,785	9	717	210	5,613	6,487	398	44	501	3,997
24	32	462	2	119	35	932	1,077	66	7	83	663
25	150	2,157	7	556	163	4,347	5,024	308	34	388	3,095
26	206	2,952	10	760	222	5,950	6,876	422	46	531	4,236
27	62	890	3	229	67	1,793	2,072	127	14	160	1,277
28	74	1,063	4	274	80	2,143	2,476	152	17	191	1,526
29	17	243	1	63	18	489	565	35	4	44	348
30	111	1,593	5	410	120	3,212	3,712	228	25	287	2,287
31	307	4,396	15	1,132	331	8,862	10,242	628	69	791	6,310
32	636	9,121	31	2,349	687	18,385	21,247	1,303	144	1,642	13,091
33	78	1,114	4	287	84	2,245	2,594	159	18	200	1,598
34	200	2,863	10	738	216	5,772	6,670	409	45	515	4,110
Grand Total	6,200	88,900	300	22,900	6,700	179,200	207,100	12,700	1,400	16,000	127,600

Table C-11, continued

SMSA	Country 12	13	14	15	16	17	18	19	20	21	Total
1	2	565	70	70	252	427	296	21	1,495	26	6,750
2	1	280	34	35	125	211	146	10	740	13	3,342
3	0	136	17	17	61	103	71	5	360	6	1,626
4	0	50	6	6	22	38	26	2	132	2	595
5	0	8	1	1	3	6	4	0	20	0	90
6	0	3	0	0	1	2	1	0	7	0	30
7	3	819	101	102	365	619	429	31	2,170	37	9,794
8	9	2,664	328	331	1,187	2,015	1,396	100	7,056	122	31,851
9	0	82	10	10	37	62	43	3	218	4	984
10	1	359	44	45	160	272	188	13	951	16	4,293
11	3	758	93	94	338	573	397	28	2,007	35	9,062
12	24	6,875	846	854	3,063	5,199	3,603	258	18,208	314	82,196
13	8	2,168	267	269	966	1,639	1,136	81	5,741	99	25,917
14	2	527	65	66	235	399	276	20	1,396	24	6,302
15	0	120	15	15	54	91	63	5	318	5	1,437
16	3	940	116	117	419	711	493	35	2,489	43	11,238
17	3	816	100	101	363	617	427	31	2,160	37	9,750
18	5	1,299	160	161	579	983	681	49	3,441	59	15,535
19	5	1,388	171	172	618	1,049	727	52	3,675	63	16,591
20	21	5,997	738	745	2,672	4,535	3,143	225	15,881	274	71,693
21	2	497	61	62	221	376	261	19	1,317	23	5,944
22	15	4,374	538	544	1,949	3,308	2,292	164	11,584	200	52,295
23	9	2,672	329	332	1,191	2,021	1,400	100	7,078	122	31,950
24	2	444	55	55	198	336	233	17	1,175	20	5,305
25	7	2,069	255	257	922	1,565	1,084	78	5,481	95	24,741
26	10	2,832	349	352	1,262	2,141	1,484	106	7,500	129	33,856
27	3	853	105	106	380	645	447	32	2,260	39	10,201
28	4	1,021	126	127	455	772	535	38	2,703	47	12,203
29	1	233	29	29	104	176	122	9	616	11	2,782
30	5	1,529	188	190	681	1,156	801	57	4,049	70	18,277
31	15	4,219	519	524	1,880	3,191	2,211	158	11,174	193	50,444
32	31	8,754	1,078	1,088	3,900	6,620	4,588	328	23,184	400	104,660
33	4	1,068	132	133	476	808	560	40	2,829	49	12,772
34	10	2,748	338	341	1,224	2,078	1,440	103	7,276	126	32,847
Grand Total	300	85,300	10,500	10,600	38,000	64,500	44,700	3,200	225,900	3,900	1,019,770

Table C-12, continued

SMSA	Country										
	12	13	14	15	16	17	18	19	20	21	Total
1	2	707	85	88	315	522	371	27	1,872	33	8,452
2	1	350	42	44	156	258	184	13	927	16	4,186
3	1	170	21	21	76	126	89	7	451	8	2,037
4	0	62	8	8	28	46	33	2	165	3	744
5	0	9	1	1	4	7	5	0	25	0	113
6	0	3	0	0	1	2	2	0	8	0	38
7	3	1,026	124	128	457	757	538	39	2,718	48	12,268
8	10	3,335	403	415	1,486	2,461	1,749	128	8,831	156	39,867
9	0	103	12	13	46	76	54	4	273	5	1,232
10	1	450	54	56	200	332	236	17	1,191	21	5,375
11	3	949	115	118	423	700	498	36	2,513	44	11,344
12	26	8,607	1,040	1,072	3,836	6,350	4,513	330	22,790	403	102,881
13	8	2,714	328	338	1,209	2,002	1,423	104	7,186	127	32,438
14	2	661	80	82	294	487	346	25	1,749	31	7,897
15	0	151	18	19	67	111	79	6	399	7	1,800
16	4	1,177	142	147	525	868	617	45	3,117	55	14,070
17	3	1,021	123	127	455	753	535	39	2,703	48	12,202
18	5	1,627	197	203	725	1,201	853	62	4,309	76	19,450
19	5	1,738	210	216	775	1,282	911	67	4,602	81	20,774
20	22	7,509	907	935	3,347	5,540	3,937	288	19,884	352	89,759
21	2	623	75	78	278	460	327	24	1,650	29	7,446
22	16	5,475	661	682	2,440	4,040	2,871	210	14,499	256	65,450
23	10	3,345	404	417	1,491	2,468	1,754	128	8,859	157	39,989
24	2	555	67	69	248	410	291	21	1,470	26	6,638
25	8	2,591	313	323	1,155	1,912	1,358	99	6,860	121	30,968
26	11	3,546	428	442	1,580	2,616	1,859	136	9,389	166	42,385
27	3	1,069	129	133	476	788	560	41	2,830	50	12,773
28	4	1,277	154	159	569	942	670	49	3,382	60	15,265
29	1	292	35	36	130	215	153	11	772	14	3,484
30	6	1,914	231	238	853	1,412	1,004	73	5,069	9	22,881
31	16	5,281	638	658	2,354	3,897	2,769	203	13,985	247	63,132
32	33	10,957	1,323	1,365	4,884	8,085	5,745	421	29,014	513	130,975
33	4	1,338	162	167	596	987	701	51	3,543	63	15,992
34	10	3,440	415	428	1,533	2,538	1,804	132	9,108	161	41,117
Grand Total	320	106,800	12,900	13,300	47,600	78,800	56,000	4,100	282,800	5,000	1,276,620

Table C-13

1969 EUROPE TO U.S. TONNAGE
AIR CARGO ONLY
(Short Tons)

SMSA	Country 1	2	3	4	5	6	7	8	9	10	11
1	11	22	0	24	2	62	144	3	0	16	161
2	44	85	0	94	9	240	559	10	1	62	625
3	25	49	0	54	5	139	323	6	1	36	361
4	14	28	0	31	3	78	182	3	0	20	204
5	10	20	0	22	2	55	129	2	0	14	144
6	7	13	0	15	1	37	87	2	0	10	98
7	51	99	0	109	10	279	650	12	2	72	727
8	62	120	0	132	12	337	787	14	2	87	880
9	12	23	0	25	2	64	148	3	0	16	166
10	9	18	0	20	2	51	118	2	0	13	132
11	17	34	0	37	3	95	220	4	1	24	246
12	154	299	0	330	31	839	1,957	36	5	216	2,189
13	17	32	0	35	3	90	209	4	1	23	234
14	57	110	0	121	11	308	718	13	2	79	803
15	9	17	0	19	2	49	114	2	0	13	127
16	35	68	0	76	7	192	448	8	1	50	501
17	21	41	0	45	4	116	270	5	1	30	302
18	40	77	0	85	8	217	505	9	1	56	565
19	24	46	0	51	5	129	300	6	1	33	336
20	105	203	0	224	21	571	1,330	25	4	147	1,488
21	24	46	0	51	5	129	300	6	1	33	336
22	77	149	0	164	15	419	977	18	3	108	1,092
23	71	137	0	152	14	386	901	17	2	100	1,007
24	5	10	0	11	1	28	65	1	0	7	72
25	61	119	0	131	12	334	779	14	2	86	871
26	38	73	0	80	8	204	475	9	1	53	531
27	16	31	0	35	3	88	205	4	1	23	230
28	22	42	0	46	4	117	274	5	1	30	306
29	16	31	0	34	3	86	201	4	1	22	225
30	105	203	0	224	21	571	1,330	25	4	147	1,488
31	124	240	0	265	25	675	1,573	29	4	174	1,759
32	309	598	0	660	62	1,680	3,917	72	10	433	4,381
33	26	50	0	55	5	140	327	6	1	36	365
34	98	190	0	209	20	533	1,243	23	3	137	1,390
Grand Total	3,000	5,800	0	6,400	600	16,300	38,000	700	100	4,200	42,500

Table C-13, continued

SMSA	Country 12	13	14	15	16	17	18	19	20	21	Total
1	0	25	2	5	33	19	43	0	137	3	714
2	0	96	7	18	129	74	168	1	531	12	2,764
3	0	55	4	10	75	42	97	1	307	7	1,598
4	0	31	2	6	42	24	55	0	173	4	902
5	0	22	2	4	30	17	39	0	123	3	639
6	0	15	1	3	20	12	26	0	83	2	432
7	0	111	9	21	150	86	195	2	617	14	3,215
8	0	135	10	25	182	104	236	2	747	17	3,892
9	0	25	2	5	34	19	44	0	141	3	733
10	0	20	2	4	27	16	35	0	112	2	583
11	0	38	3	7	51	29	66	1	209	5	1,090
12	0	335	26	62	453	257	587	5	1,859	41	9,682
13	0	36	3	7	48	28	63	1	199	4	1,034
14	0	123	9	23	166	95	215	2	682	15	3,553
15	0	19	1	4	26	15	34	0	108	2	564
16	0	77	6	14	104	59	135	1	426	9	2,218
17	0	46	4	9	62	35	81	1	256	6	1,335
18	0	86	7	16	117	67	152	1	480	11	2,500
19	0	51	4	9	70	39	90	1	285	6	1,485
20	0	228	18	42	308	175	399	4	1,264	28	6,580
21	0	51	4	9	70	39	90	1	285	6	1,485
22	0	167	13	31	226	128	293	3	928	21	4,832
23	0	154	12	28	209	118	270	2	856	19	4,456
24	0	11	1	2	15	9	19	0	61	1	320
25	0	133	10	25	180	102	234	2	740	16	3,854
26	0	81	6	15	110	63	143	1	451	10	2,350
27	0	35	3	6	48	27	62	1	195	4	1,015
28	0	47	4	9	63	36	82	1	260	6	1,354
29	0	34	3	6	47	26	60	1	191	4	996
30	0	228	18	42	308	175	399	4	1,264	28	6,580
31	0	269	21	50	364	207	472	4	1,495	33	7,783
32	0	670	52	124	907	515	1,175	10	3,722	82	19,381
33	0	56	4	10	76	43	98	1	310	7	1,617
34	0	213	16	39	288	164	373	3	1,180	26	6,148
Grand Total	0	6,500	500	1,200	8,800	5,000	11,400	100	36,100	800	188,000

Table C-14

1975 EUROPE TO U.S. FORECAST
AIR PLUS SURFACE CARGO VALUED GREATER THAN $1.00 PER POUND
(Short Tons)

	Country										
SMSA	1	2	3	4	5	6	7	8	9	10	11
1	49	96	0	72	6	268	624	19	1	60	585
2	199	387	0	292	26	1,088	2,528	77	4	243	2,368
3	119	232	0	174	15	650	1,511	46	1	145	1,416
4	59	114	0	86	8	321	747	23	1	72	699
5	45	87	0	66	6	245	569	17	1	55	533
6	29	57	0	43	4	159	369	11	1	35	346
7	238	463	0	349	31	1,301	3,024	92	5	291	2,832
8	299	582	0	438	39	1,635	3,801	116	6	365	3,560
9	51	100	0	75	7	280	652	20	1	63	611
10	41	79	0	60	5	223	518	16	1	50	485
11	79	154	0	116	10	432	1,003	31	2	96	940
12	704	1,372	0	1,033	91	3,853	8,957	273	15	861	8,390
13	73	142	0	107	9	400	930	28	2	89	871
14	255	498	0	375	33	1,398	3,251	99	6	312	3,045
15	38	74	0	56	5	208	484	15	1	47	453
16	159	309	0	233	21	868	2,018	62	3	194	1,890
17	88	171	0	129	11	481	1,118	34	2	107	1,047
18	180	350	0	264	23	984	2,288	70	4	220	2,143
19	104	203	0	153	14	571	1,328	41	2	128	1,244
20	465	907	0	682	60	2,546	5,918	181	10	569	5,544
21	108	210	0	158	14	591	1,374	42	2	132	1,287
22	341	666	0	501	44	1,869	4,346	133	7	418	4,070
23	317	617	0	465	41	1,734	4,030	123	7	387	3,775
24	22	43	0	32	3	120	279	9	0	27	262
25	260	507	0	381	34	1,423	3,308	101	6	318	3,098
26	164	320	0	241	21	899	2,089	64	4	201	1,957
27	75	147	0	111	10	413	960	29	2	92	899
28	105	205	0	154	14	575	1,336	41	2	128	1,251
29	64	125	0	94	8	350	814	25	1	78	763
30	481	938	0	706	62	2,633	6,121	187	10	588	5,734
31	563	1,097	0	826	73	3,080	7,161	219	12	688	6,707
32	1,378	2,686	0	2,022	178	7,542	17,532	535	30	1,685	16,422
33	121	236	0	177	16	661	1,537	47	3	148	1,440
34	434	847	0	638	56	2,379	5,529	169	9	531	5,179
Grand Total	13,900	27,100	0	20,400	1,800	76,100	176,900	5,400	300	17,000	165,700

Table C-14, continued

SMSA	Country 12	13	14	15	16	17	18	19	20	21	Total
1	0	105	6	15	111	58	188	1	524	11	2,798
2	0	427	24	60	450	233	760	4	2,121	44	11,334
3	0	255	15	36	269	139	455	3	1,268	26	6,775
4	0	126	7	18	133	69	225	1	626	13	3,347
5	0	96	5	14	101	52	171	1	478	10	2,552
6	0	62	4	9	66	34	111	1	309	6	1,654
7	0	511	29	72	538	279	909	5	2,537	53	13,556
8	0	642	37	90	677	350	1,143	6	3,188	67	17,039
9	0	110	6	15	116	60	196	1	547	11	2,922
10	0	88	5	12	92	48	156	1	435	9	2,323
11	0	170	10	24	179	92	302	2	841	18	4,497
12	0	1,514	86	213	1,595	825	2,694	15	7,514	157	40,155
13	0	157	9	22	166	86	280	2	780	16	4,169
14	0	549	31	77	579	300	978	6	2,727	57	14,573
15	0	82	5	11	86	45	146	1	406	8	2,170
16	0	341	19	48	359	186	607	3	1,693	35	9,047
17	0	189	11	27	199	103	336	2	938	20	5,012
18	0	387	22	54	407	211	688	4	1,919	40	10,255
19	0	224	13	32	236	122	399	2	1,114	23	5,954
20	0	1,000	57	141	1,054	545	1,780	10	4,965	104	26,531
21	0	232	13	33	245	127	413	2	1,153	24	6,160
22	0	735	42	103	774	400	1,307	7	3,646	76	19,481
23	0	681	39	96	718	371	1,212	7	3,381	71	18,068
24	0	47	3	7	50	26	84	0	234	5	1,252
25	0	559	32	79	589	305	995	6	2,775	58	14,827
26	0	353	20	50	372	193	628	4	1,753	37	9,367
27	0	162	9	23	171	88	289	2	805	17	4,304
28	0	226	13	32	238	123	402	2	1,121	23	5,989
29	0	138	8	19	145	75	245	1	683	14	3,649
30	0	1,035	59	145	1,090	564	1,841	10	5,135	107	27,442
31	0	1,210	69	170	1,275	660	2,153	12	6,007	125	32,100
32	0	2,963	168	416	3,122	1,615	5,272	30	14,707	307	78,593
33	0	260	15	37	274	142	462	3	1,290	27	6,892
34	0	935	53	131	985	509	1,663	9	4,639	97	24,787
Grand Total	0	29,900	1,700	4,200	31,500	16,300	53,200	300	148,400	3,100	793,200

Table C-15

1980 EUROPE TO U.S. FORECAST
AIR PLUS SURFACE CARGO VALUED GREATER THAN $1.00 PER POUND
(Short Tons)

SMSA	Country 1	2	3	4	5	6	7	8	9	10	11
1	62	120	0	91	8	338	785	23	1	76	722
2	260	505	0	381	34	1,423	3,305	98	4	320	3,038
3	160	311	0	234	21	874	2,031	60	3	196	1,867
4	71	137	0	103	9	386	897	27	1	87	825
5	57	111	0	84	7	313	728	22	1	70	669
6	36	70	0	52	5	196	455	13	1	44	418
7	318	619	0	467	41	1,741	4,045	120	5	391	3,719
8	412	802	0	605	53	2,258	5,246	155	7	508	4,823
9	65	127	0	96	8	358	832	25	1	80	765
10	52	101	0	76	7	285	661	20	1	64	608
11	104	201	0	152	13	567	1,317	39	2	127	1,211
12	929	1,807	0	1,363	120	5,088	11,818	349	15	1,143	10,864
13	94	183	0	138	12	516	1,198	35	2	116	1,102
14	334	650	0	490	43	1,829	4,249	126	5	411	3,906
15	47	92	0	69	6	258	600	18	1	58	551
16	206	402	0	303	27	1,130	2,625	78	3	254	2,414
17	107	208	0	157	14	585	1,358	40	2	131	1,248
18	235	457	0	345	30	1,287	2,990	88	4	289	2,749
19	134	260	0	196	17	733	1,703	50	2	165	1,566
20	599	1,166	0	880	77	3,283	7,626	226	10	738	7,011
21	142	277	0	209	18	780	1,813	54	2	175	1,666
22	440	856	0	646	57	2,411	5,600	166	7	542	5,148
23	410	798	0	602	53	2,247	5,219	154	7	505	4,797
24	28	54	0	41	4	151	351	10	0	34	323
25	322	627	0	473	42	1,765	4,099	121	5	397	3,768
26	210	408	0	308	27	1,148	2,667	79	3	258	2,452
27	101	197	0	149	13	555	1,290	38	2	125	1,186
28	146	284	0	215	19	801	1,860	55	2	180	1,710
29	76	148	0	112	10	417	968	29	1	94	890
30	638	1,241	0	936	82	3,493	8,114	240	10	785	7,459
31	739	1,438	0	1,085	95	4,048	9,403	278	12	910	8,644
32	1,784	3,472	0	2,618	230	9,772	22,700	671	29	2,196	20,868
33	163	317	0	239	21	893	2,075	61	3	201	1,908
34	560	1,090	0	822	72	3,067	7,125	211	9	689	6,550
Grand Total	18,600	36,200	0	27,300	2,400	101,900	236,700	7,000	300	22,900	217,600

Table C-15, continued

SMSA	Country 12	13	14	15	16	17	18	19	20	21	Total
1	0	132	8	17	129	72	236	1	668	13	3,498
2	0	556	32	73	542	304	993	5	2,798	56	14,725
3	0	341	20	45	333	187	610	3	1,719	34	9,049
4	0	151	9	20	147	83	270	1	760	15	3,999
5	0	122	7	16	119	67	219	1	616	12	3,243
6	0	76	4	10	75	42	137	1	385	8	2,027
7	0	680	39	89	663	373	1,215	6	3,425	68	18,023
8	0	882	51	115	860	483	1,576	8	4,441	89	23,375
9	0	140	8	18	136	77	250	1	704	14	3,707
10	0	111	6	15	108	61	199	1	560	11	2,947
11	0	221	13	29	216	121	396	2	1,115	22	5,869
12	0	1,987	115	260	1,937	1,088	3,550	18	10,005	200	52,657
13	0	201	12	26	196	110	360	2	1,015	20	5,340
14	0	714	41	93	696	391	1,276	6	3,597	72	18,932
15	0	101	6	13	98	55	180	1	508	10	2,673
16	0	441	26	58	430	242	789	4	2,223	44	11,698
17	0	228	13	30	223	125	408	2	1,150	23	6,050
18	0	503	29	66	490	275	898	5	2,531	51	13,323
19	0	286	17	37	279	157	512	3	1,442	29	7,590
20	0	1,282	74	168	1,250	702	2,291	12	6,457	129	33,982
21	0	305	18	40	297	167	545	3	1,535	31	8,077
22	0	942	54	123	918	516	1,682	9	4,741	95	24,952
23	0	877	51	115	855	481	1,568	8	4,418	88	23,253
24	0	59	3	8	58	32	105	1	297	6	1,565
25	0	689	40	90	672	378	1,231	6	3,470	69	18,264
26	0	448	26	59	437	246	801	4	2,258	45	11,882
27	0	217	13	28	211	119	388	2	1,092	22	5,749
28	0	313	18	41	305	171	559	3	1,575	31	8,289
29	0	163	9	21	159	89	291	1	820	16	4,315
30	0	1,364	79	178	1,330	747	2,437	12	6,869	137	36,152
31	0	1,581	91	207	1,541	866	2,825	14	7,961	159	41,899
32	0	3,817	221	499	3,721	2,091	6,819	35	19,219	384	101,147
33	0	349	20	46	340	191	623	3	1,757	35	9,246
34	0	1,198	69	157	1,168	656	2,140	11	6,033	120	31,749
Grand Total	0	39,800	2,300	5,200	38,800	21,800	71,100	360	200,400	4,000	1,054,660

Table C-16

1985 EUROPE TO U.S. FORECAST
AIR PLUS SURFACE CARGO VALUED GREATER THAN $1.00 PER POUND
(Short Tons)

	Country										
SMSA	1	2	3	4	5	6	7	8	9	10	11
1	78	151	0	113	10	425	987	29	1	97	891
2	340	661	0	496	44	1,859	4,319	127	5	423	3,898
3	215	418	0	314	28	1,174	2,729	80	3	267	2,463
4	85	165	0	124	11	464	1,079	32	1	106	973
5	73	142	0	107	9	400	930	27	1	91	840
6	44	86	0	64	6	241	561	16	1	55	506
7	425	829	0	622	55	2,328	5,410	159	6	530	4,882
8	569	1,109	0	832	73	3,116	7,240	213	8	709	6,534
9	83	163	0	122	11	457	1,062	31	1	104	958
10	66	129	0	97	9	363	844	25	1	83	762
11	136	265	0	199	17	744	1,730	51	2	169	1,561
12	1,226	2,388	0	1,792	158	6,710	15,590	458	18	1,526	14,069
13	121	236	0	177	16	665	1,544	45	2	151	1,393
14	437	850	0	638	56	2,390	5,553	163	6	544	5,012
15	58	114	0	85	8	320	743	22	1	73	671
16	269	523	0	393	35	1,470	3,415	100	4	334	3,082
17	130	253	0	190	17	710	1,649	48	2	161	1,488
18	307	598	0	449	39	1,682	3,908	115	5	383	3,527
19	172	335	0	251	22	940	2,184	64	3	214	1,971
20	773	1,505	0	1,130	99	4,229	9,827	289	11	962	8,868
21	188	366	0	275	24	1,029	2,391	70	3	234	2,158
22	567	1,105	0	829	73	3,106	7,216	212	8	706	6,512
23	531	1,035	0	777	68	2,908	6,757	198	8	661	6,097
24	35	68	0	51	4	190	442	13	1	43	399
25	399	778	0	584	51	2,186	5,080	149	6	497	4,584
26	268	521	0	391	34	1,465	3,403	100	4	333	3,071
27	136	265	0	199	18	746	1,734	51	2	170	1,564
28	204	397	0	298	26	1,115	2,590	76	3	254	2,337
29	91	176	0	132	12	496	1,152	34	1	113	1,039
30	845	1,647	0	1,236	109	4,628	10,753	316	13	1,053	9,704
31	971	1,891	0	1,419	125	5,314	12,348	363	14	1,209	11,143
32	2,311	4,501	0	3,378	297	12,649	29,390	863	34	2,877	26,523
33	220	429	0	322	28	1,205	2,801	82	3	274	2,528
34	722	1,406	0	1,055	93	3,952	9,182	270	11	899	8,286
Grand Total	24,900	48,500	0	36,400	3,200	136,300	316,700	9,300	370	31,000	285,800

Table C-16, continued

SMSA	Country 12	13	14	15	16	17	18	19	20	21	Total
1	0	166	9	20	149	91	297	1	844	17	4,377
2	0	727	41	86	653	398	1,298	5	3,692	72	19,145
3	0	459	26	54	413	252	820	3	2,332	46	12,095
4	0	182	10	21	163	99	324	1	922	18	4,781
5	0	157	9	19	141	86	280	1	795	16	4,124
6	0	94	5	11	85	52	169	1	479	9	2,486
7	0	911	51	108	818	499	1,626	7	4,625	91	23,981
8	0	1,219	69	144	1,095	668	2,176	9	6,189	121	32,092
9	0	179	10	21	161	98	319	1	908	18	4,706
10	0	142	8	17	128	78	254	1	722	14	3,742
11	0	291	16	34	262	159	520	2	1,478	29	7,666
12	0	2,624	148	310	2,358	1,437	4,686	19	13,326	261	69,104
13	0	260	15	31	234	142	464	2	1,320	26	6,844
14	0	935	53	110	840	412	1,669	7	4,747	93	24,615
15	0	125	7	15	112	69	223	1	635	12	3,295
16	0	575	32	68	517	315	1,027	4	2,919	57	15,138
17	0	273	16	33	249	152	496	2	1,409	28	7,309
18	0	658	37	78	591	360	1,175	5	3,340	65	17,322
19	0	368	21	43	330	201	657	3	1,867	37	9,682
20	0	1,654	93	195	1,486	906	2,954	12	8,400	164	43,559
21	0	402	23	48	362	220	719	3	2,044	40	10,600
22	0	1,214	68	144	1,091	665	2,169	9	6,168	121	31,985
23	0	1,137	64	134	1,022	623	2,031	8	5,775	113	29,948
24	0	74	4	9	67	41	133	1	378	7	1,958
25	0	855	48	101	768	468	1,527	6	4,342	85	22,515
26	0	573	32	68	515	314	1,023	4	2,909	57	15,086
27	0	292	16	34	262	160	521	2	1,482	29	7,684
28	0	436	25	52	392	239	779	3	2,214	43	11,480
29	0	194	11	23	174	106	346	1	984	19	5,105
30	0	1,810	102	214	1,626	991	3,232	13	9,191	180	47,664
31	0	2,078	117	246	1,868	1,138	3,712	15	10,554	207	54.730
32	0	4,946	278	585	4.445	2,710	8,835	36	25,121	492	130,271
33	0	471	27	56	424	258	842	3	2,394	47	12,415
34	0	1,545	87	183	1,389	847	2,760	11	7,848	154	40,697
Grand Total	0	53,300	3,000	6,300	47,900	29,200	95,200	390	270,700	5,300	1,403,760

Table C-17

1969 CANADA TO U.S. TONNAGE
AIR CARGO ONLY
(Short Tons)

SMSA	CMA										
	1	2	3	4	5	6	7	8	9	10	11
1	0	0	0	0	9	1	3	1	1	1	11
2	1	0	2	2	35	3	12	5	3	2	41
3	0	0	1	1	20	2	7	3	2	1	24
4	0	0	1	1	12	1	4	2	1	1	13
5	0	0	0	0	8	1	3	1	1	1	9
6	0	0	0	0	6	0	2	1	1	0	6
7	1	0	2	2	41	3	14	6	4	3	48
8	1	0	3	2	50	4	16	7	5	3	58
9	0	0	1	0	9	1	3	1	1	1	11
10	0	0	0	0	7	1	2	1	1	1	9
11	0	0	1	1	14	1	5	2	1	1	16
12	2	0	7	6	124	10	41	17	12	8	144
13	0	0	1	1	13	1	4	2	1	1	15
14	1	0	2	2	45	4	15	6	4	3	53
15	0	0	0	0	7	1	2	1	1	0	8
16	1	0	2	1	28	2	9	4	3	2	33
17	0	0	1	1	17	1	6	2	2	1	20
18	1	0	2	1	32	3	11	4	3	2	37
19	0	0	1	1	19	2	6	3	2	1	22
20	2	0	5	4	84	7	28	12	8	6	98
21	0	0	1	1	19	2	6	3	2	1	22
22	1	0	3	3	62	5	20	9	6	4	72
23	1	0	3	3	57	5	19	8	5	4	66
24	0	0	0	0	4	0	1	1	0	0	5
25	1	0	3	2	49	4	16	7	5	3	57
26	1	0	2	1	30	2	10	4	3	2	35
27	0	0	1	1	13	1	4	2	1	1	15
28	0	0	1	1	17	1	6	2	2	1	20
29	0	0	1	1	13	1	4	2	1	1	15
30	2	0	5	4	84	7	28	12	8	6	98
31	2	0	5	5	100	8	33	14	9	7	116
32	5	1	13	12	248	20	82	34	24	17	288
33	0	0	1	1	21	2	7	3	2	1	24
34	2	0	4	4	79	6	26	11	7	5	91
Grand Total	46	8	129	112	2,405	195	792	333	229	164	2,794

Table C-17, continued

SMSA	CMA 12	13	14	15	16	17	18	19	Total
1	2	1	0	0	0	1	3	0	35
2	8	3	1	1	2	3	11	1	135
3	4	2	0	0	1	2	7	1	78
4	3	1	0	0	1	1	4	0	44
5	2	1	0	0	0	1	3	0	31
6	1	1	0	0	0	0	2	0	21
7	9	4	1	1	2	3	13	1	157
8	11	5	1	1	3	4	16	1	190
9	2	1	0	0	1	1	3	0	36
10	2	1	0	0	0	1	2	0	29
11	3	1	0	0	1	1	5	0	53
12	27	12	2	2	7	9	40	3	474
13	3	1	0	0	1	1	4	0	51
14	10	4	1	1	2	3	15	1	174
15	2	1	0	0	0	1	2	0	28
16	6	3	1	1	2	2	9	1	109
17	4	2	0	0	1	1	6	0	65
18	7	3	1	1	2	2	10	1	122
19	4	2	0	0	1	1	6	1	73
20	18	8	2	2	5	6	27	2	322
21	4	2	0	0	1	1	6	1	73
22	13	6	1	1	3	5	20	2	236
23	12	5	1	1	3	4	18	2	218
24	1	0	0	0	0	0	1	0	16
25	11	5	1	1	3	4	16	1	189
26	7	3	1	1	2	2	10	1	115
27	3	1	0	0	1	1	4	0	50
28	4	2	0	0	1	1	6	0	66
29	3	1	0	0	1	1	4	0	49
30	18	8	2	2	5	6	27	2	322
31	22	9	2	2	5	7	32	3	381
32	54	23	5	5	14	18	80	7	948
33	5	2	0	0	1	2	7	1	79
34	17	7	1	1	4	6	25	2	301
Grand Total	525	227	44	45	131	178	779	64	9,200

Table C-18

1975 CANADA TO U.S. FORECAST
AIR PLUS SURFACE CARGO VALUED GREATER THAN $1.00 PER POUND
(Short Tons)

SMSA	CMA 1	2	3	4	5	6	7	8	9	10	11
1	5	1	15	13	273	22	90	38	26	19	317
2	21	4	59	52	1,106	90	364	153	105	75	1,285
3	13	2	35	31	661	54	218	92	63	45	768
4	6	1	17	15	326	26	108	45	31	22	379
5	5	1	13	12	249	20	82	34	24	17	289
6	3	1	9	8	161	13	53	22	15	11	187
7	25	5	71	62	1,322	107	436	183	126	90	1,536
8	32	6	89	78	1,662	135	547	230	158	113	1,931
9	5	1	15	13	285	23	94	39	27	19	331
10	4	1	12	11	227	18	75	31	22	15	263
11	8	2	23	20	439	36	144	61	42	30	510
12	75	13	210	183	3,917	318	1,290	542	373	267	4,551
13	8	1	22	19	407	33	134	56	39	28	472
14	27	5	76	66	1,422	115	468	197	135	97	1,652
15	4	1	11	10	212	17	70	29	20	14	246
16	17	3	47	41	882	72	291	122	84	60	1,025
17	9	2	26	23	489	40	161	68	47	33	568
18	19	3	54	47	1,000	81	329	139	95	68	1,162
19	11	2	31	27	581	47	191	80	55	40	675
20	50	9	139	121	2,588	210	852	358	246	176	3,007
21	11	2	32	28	601	49	198	83	57	41	698
22	36	7	102	89	1,900	154	626	263	181	129	2,208
23	34	6	94	82	1,762	143	581	244	168	120	2,048
24	2	0	7	6	122	10	40	17	12	8	142
25	28	5	77	67	1,446	117	476	200	138	98	1,680
26	17	3	49	43	914	74	301	127	87	62	1,062
27	8	1	22	20	420	34	138	58	40	29	488
28	11	2	31	27	584	47	192	81	56	40	679
29	7	1	19	17	356	29	117	49	34	24	414
30	51	9	143	125	2,677	217	882	371	255	182	3,110
31	60	11	168	146	3,131	254	1,031	434	298	213	3,638
32	147	26	411	358	7,666	622	2,525	1,062	730	522	8,907
33	13	2	36	31	672	55	221	93	64	46	781
34	46	8	129	113	2,418	196	796	335	230	165	2,809
Grand Total	1,480	266	4,143	3,610	77,356	6,273	25,479	10,712	7,368	5,268	89,874

Table C-18, continued

SMSA	CMA 12	13	14	15	16	17	18	19	Total
1	60	26	5	5	15	20	88	7	1,044
2	241	104	20	21	60	82	358	30	4,230
3	144	62	12	12	36	49	214	18	2,528
4	71	31	6	6	18	24	106	9	1,249
5	54	24	5	5	14	18	81	7	952
6	35	15	3	3	9	12	52	4	617
7	288	125	24	25	72	98	428	35	5,059
8	362	157	31	31	90	123	589	44	6,358
9	62	27	5	5	15	21	92	8	1,090
10	49	21	4	4	12	17	73	6	867
11	96	41	8	8	24	32	142	12	1,678
12	854	370	72	73	213	289	1,269	105	14,985
13	89	38	7	8	22	30	132	11	1,556
14	310	134	26	27	77	105	461	38	5,438
15	46	20	4	4	11	16	69	6	810
16	192	83	16	17	48	65	286	24	3,376
17	107	46	9	9	27	36	158	13	1,870
18	218	95	18	19	54	74	324	27	3,827
19	127	55	11	11	32	43	188	16	2,222
20	564	245	48	49	141	191	839	69	9,900
21	131	57	11	11	33	44	195	16	2,299
22	414	180	35	36	103	140	616	51	7,270
23	384	167	32	33	96	130	571	47	6,742
24	27	12	2	2	7	9	40	3	465
25	315	137	27	27	79	107	469	39	5,533
26	199	86	17	17	50	67	296	24	3,495
27	92	40	8	8	23	31	136	11	1,606
28	127	55	11	11	32	43	189	16	2,235
29	78	34	7	7	19	26	115	10	1,362
30	584	253	49	50	145	198	867	72	10,240
31	683	296	57	59	170	231	1,015	84	11,979
32	1,672	724	141	144	417	566	2,484	205	29,328
33	147	64	12	13	37	50	218	18	2,572
34	527	228	44	45	131	179	783	65	9,250
Grand Total	16,869	7,309	1,420	1,450	4,203	5,712	25,065	2,071	295,929

Table C-19

1980 CANADA TO U.S. FORECAST
AIR PLUS SURFACE CARGO VALUED GREATED THAN $1.00 PER POUND
(Short Tons)

SMSA	CMA 1	2	3	4	5	6	7	8	9	10	11
1	7	1	20	17	368	30	121	51	35	25	428
2	30	5	83	72	1,551	126	511	215	148	106	1,801
3	18	3	51	44	953	77	314	132	91	65	1,107
4	8	1	23	20	421	34	139	58	40	29	489
5	7	1	18	16	341	28	112	47	33	23	397
6	4	1	11	10	213	17	70	30	20	15	248
7	36	7	102	89	1,898	154	625	263	181	129	2,205
8	47	8	132	115	2,461	200	811	341	234	168	2,860
9	7	1	21	18	390	32	129	54	37	27	453
10	6	1	17	14	310	25	102	43	30	21	361
11	12	2	33	29	618	50	204	86	59	42	718
12	106	19	297	259	5,545	450	1,826	768	528	378	6,442
13	11	2	30	26	562	46	185	78	54	38	653
14	38	7	107	93	1,993	162	657	276	190	136	2,316
15	5	1	15	13	281	23	93	39	27	19	327
16	24	4	66	57	1,232	100	406	171	117	84	1,431
17	12	2	34	30	637	52	210	88	61	43	740
18	27	5	75	65	1,403	114	462	194	134	96	1,630
19	15	3	43	37	799	65	263	111	76	54	928
20	68	12	192	167	3,578	290	1,179	496	341	244	4,157
21	16	3	46	40	851	69	280	118	81	58	988
22	50	9	141	123	2,627	213	865	364	250	179	3,053
23	47	8	131	114	2,448	199	806	339	233	167	2,845
24	3	1	9	8	165	13	54	23	16	11	191
25	37	7	103	90	1,923	156	633	266	183	131	2,234
26	24	4	67	58	1,251	101	412	173	119	85	1,454
27	12	2	32	28	605	49	199	84	58	41	703
28	17	3	47	41	873	71	287	121	83	59	1,014
29	9	2	24	21	454	37	150	63	43	31	528
30	73	13	204	178	3,807	309	1,254	527	363	259	4,423
31	84	15	236	206	4,412	358	1,453	611	420	300	5,126
32	204	37	570	497	10,650	864	3,508	1,475	1,014	725	12,374
33	19	3	52	45	974	79	321	135	93	66	1,131
34	64	11	179	156	3,343	271	1,101	463	318	228	3,884
Grand Total	2,124	382	5,948	5,182	111,054	9,006	36,579	15,379	10,578	7,563	129,025

Table C-19, continued

SMSA	CMA 12	13	14	15	16	17	18	19	Total
1	80	35	7	7	20	27	119	10	1,409
2	338	147	28	29	84	114	502	42	5,932
3	208	90	17	18	52	70	309	26	3,645
4	92	40	8	8	23	31	136	11	1,611
5	74	32	6	6	19	25	111	9	1,306
6	47	20	4	4	12	16	69	6	816
7	414	179	35	36	103	140	615	51	7,260
8	537	233	45	46	134	182	798	66	9,416
9	85	37	7	7	21	29	126	10	1,493
10	68	29	6	6	17	23	101	8	1,187
11	135	58	11	12	34	46	200	17	2,364
12	1,209	524	102	104	301	409	1,797	148	21,211
13	123	53	10	11	31	42	182	15	2,151
14	35	188	37	37	108	147	646	53	7,626
15	61	27	5	5	15	21	91	8	1,077
16	269	116	23	23	67	91	399	33	4,712
17	139	60	12	12	35	47	206	17	2,437
18	306	133	26	26	76	104	455	38	5,367
19	174	76	15	15	43	59	259	21	3,057
20	780	338	66	67	194	264	1,159	96	13,688
21	185	80	16	16	46	63	276	23	3,254
22	573	248	48	49	143	194	851	70	10,051
23	534	231	45	46	133	181	793	66	9,367
24	36	16	3	3	9	12	53	4	630
25	419	182	35	36	104	142	623	51	7,357
26	273	118	23	23	68	92	405	33	4,786
27	132	57	11	11	33	45	196	16	2,316
28	190	82	16	16	47	64	283	23	3,339
29	99	43	8	9	25	34	147	12	1,738
30	830	360	70	71	207	281	1,233	102	14,563
31	962	417	81	83	240	326	1,430	118	16,877
32	2,322	1,006	196	200	579	786	3,451	285	40,743
33	212	92	18	18	53	72	315	26	3,725
34	729	316	61	63	182	247	1,083	89	12,789
Grand Total	24,217	10,493	2,039	2,082	6,034	8,200	35,984	2,973	424,842

Table C-20

1985 CANADA TO U.S. FORECAST
AIR PLUS SURFACE CARGO VALUED GREATER THAN $1.00 PER POUND

(Short Tons)

	CMA										
SMSA	1	2	3	4	5	6	7	8	9	10	11
1	10	2	27	23	497	40	164	69	47	34	578
2	42	7	116	101	2,174	176	716	301	207	148	2,526
3	26	5	74	64	1,374	111	452	190	131	94	1,596
4	10	2	29	25	543	44	179	75	52	37	631
5	9	2	25	22	468	38	154	65	45	32	544
6	5	1	15	13	282	23	93	39	27	19	328
7	52	9	146	127	2,724	221	897	377	259	185	3,164
8	70	13	195	170	3,645	296	1,201	505	347	248	4,235
9	10	2	29	25	535	43	176	74	51	36	621
10	8	1	23	20	425	34	140	59	40	29	494
11	17	3	47	41	871	71	287	121	83	59	1,012
12	150	27	420	366	7,849	637	2,585	1,087	748	535	9,119
13	15	3	42	36	777	63	256	108	74	53	903
14	53	10	150	130	2,796	227	921	387	266	190	3,248
15	7	1	20	17	374	30	123	52	36	25	435
16	33	6	92	80	1,719	139	566	238	164	117	1,998
17	16	3	44	39	830	67	273	115	79	57	964
18	38	7	105	92	1,967	160	648	272	187	134	2,286
19	21	4	59	51	1,100	89	362	152	105	75	1,278
20	95	17	265	231	4,947	401	1,630	685	471	337	5,748
21	23	4	64	56	1,204	98	397	167	115	82	1,399
22	69	12	195	170	3,633	295	1,197	503	346	247	4,221
23	65	12	182	159	3,401	276	1,120	471	324	232	3,952
24	4	1	12	10	222	18	73	31	21	15	258
25	49	9	137	119	2,557	207	842	354	244	174	2,971
26	33	6	92	80	1,713	139	564	237	163	117	1,991
27	17	3	47	41	873	71	287	121	83	59	1,014
28	25	4	70	61	1,304	106	429	181	124	89	1,515
29	11	2	31	27	580	47	191	80	55	39	674
30	104	19	290	253	5,413	439	1,783	750	516	369	6,289
31	119	21	333	290	6,216	504	2,047	861	592	423	7,222
32	283	51	793	690	14,796	1,200	4,873	2,049	1,409	1,008	17,190
33	27	5	76	66	1,410	114	464	195	134	96	1,638
34	88	16	248	216	4,622	375	1,522	640	440	315	5,370
Grand Total	3,050	548	8,540	7,440	159,434	12,930	52,514	22,079	15,187	10,858	185,233

Table C-20, continued

SMSA	CMA								
	12	13	14	15	16	17	18	19	Total
1	108	47	9	9	27	37	161	13	1,902
2	474	205	40	41	118	161	705	58	8,319
3	300	130	25	26	75	101	445	37	5,258
4	118	51	10	10	30	40	176	15	2,077
5	102	44	9	9	25	35	152	13	1,792
6	62	27	5	5	15	21	91	8	1,080
7	594	257	50	51	148	201	883	73	10,420
8	795	344	67	68	198	269	1,181	98	13,944
9	117	51	10	10	29	39	173	14	2,045
10	93	40	8	8	23	31	138	11	1,626
11	190	82	16	16	47	64	282	23	3,331
12	1,711	742	144	147	426	580	2,543	210	30,025
13	170	73	14	15	42	57	252	21	2,974
14	610	264	51	52	152	206	906	75	10,695
15	82	35	7	7	20	28	121	10	1,431
16	375	162	32	32	93	127	557	46	6,578
17	181	78	15	16	45	61	269	22	3,176
18	429	186	36	37	107	145	637	53	7,526
19	240	104	20	21	60	81	356	29	4,207
20	1,079	467	91	93	269	365	1,603	132	18,926
21	263	114	22	23	65	89	390	32	4,606
22	792	343	67	68	197	268	1,177	97	13,897
23	742	321	62	64	185	251	1,102	91	13,012
24	48	21	4	4	12	16	72	6	851
25	558	242	47	48	139	189	829	68	9,782
26	374	162	31	32	93	127	555	46	6,555
27	190	82	16	16	47	64	283	23	3,339
28	284	123	24	24	71	96	422	35	4,988
29	126	55	11	11	32	43	188	16	2,218
30	1,180	511	99	101	294	400	1,754	145	20,709
31	1,355	587	114	116	338	459	2,014	166	23,780
32	3,226	1,398	272	277	804	1,093	4,794	396	56,602
33	307	133	26	26	77	104	457	38	5,394
34	1,008	437	85	87	251	341	1,498	124	17,683
Grand Total	34,767	15,064	2,927	2,988	8,662	11,773	51,660	4,268	609,922

Table C-21

1969 U.S. TO CANADA TONNAGE
AIR CARGO ONLY
(Short Tons)

	CMA										
SMSA	1	2	3	4	5	6	7	8	9	10	11
1	5	1	7	6	47	8	8	4	4	9	40
2	2	0	3	3	23	4	4	2	2	5	20
3	1	0	2	1	11	2	2	1	1	2	10
4	0	0	0	0	4	1	1	0	0	1	4
5	0	0	0	0	1	0	0	0	0	0	1
6	0	0	0	0	0	0	0	0	0	0	0
7	7	1	10	8	69	12	12	5	6	13	59
8	23	5	33	27	225	38	39	17	18	43	191
9	1	0	1	1	7	1	1	1	1	1	6
10	3	1	5	4	30	5	5	2	2	6	26
11	6	1	9	8	64	11	11	5	5	12	54
12	58	12	87	71	582	98	102	44	48	112	493
13	18	4	27	22	183	31	32	14	15	35	155
14	4	1	7	5	44	7	8	3	4	9	38
15	1	0	2	1	10	2	2	1	1	2	9
16	8	2	12	10	79	13	14	6	7	15	67
17	7	1	10	8	69	12	12	5	6	13	58
18	11	2	16	13	110	18	19	8	9	21	93
19	12	2	17	14	117	20	21	9	10	23	99
20	51	11	75	62	506	85	89	38	41	98	429
21	4	1	6	5	42	7	7	3	3	8	36
22	37	8	55	45	369	62	65	28	30	71	313
23	23	5	34	28	226	38	40	17	19	44	192
24	4	1	6	5	37	6	7	3	3	7	32
25	18	4	26	21	175	29	31	13	14	34	148
26	24	5	35	29	238	40	42	18	20	46	202
27	7	2	11	9	72	12	13	5	6	14	61
28	9	2	13	11	86	15	15	6	7	17	73
29	2	0	3	2	20	3	3	1	2	4	17
30	13	3	19	16	129	23	23	10	11	25	110
31	36	8	53	43	356	60	62	27	29	69	302
32	74	16	110	90	741	125	130	56	61	143	628
33	9	2	13	11	90	15	16	7	7	17	76
34	23	5	34	28	232	39	41	17	19	45	197
Grand Total	724	153	1,073	878	7,206	1,215	1,262	541	591	1,389	6,112

Table C-21, continued

SMSA	CMA 12	13	14	15	16	17	18	19	Total
1	4	9	5	4	7	8	16	3	195
2	2	4	2	2	3	4	8	1	96
3	1	2	1	1	2	2	4	1	47
4	0	1	0	0	1	1	1	0	17
5	0	0	0	0	0	0	0	0	3
6	0	0	0	0	0	0	0	0	1
7	6	13	7	6	10	11	24	4	283
8	18	43	22	20	32	37	76	14	922
9	1	1	1	1	1	1	2	0	28
10	2	6	3	3	4	5	10	2	124
11	5	12	6	6	9	10	22	4	262
12	47	111	57	52	82	95	198	37	2,386
13	15	35	18	16	26	30	62	12	749
14	4	9	4	4	6	7	15	3	182
15	1	2	1	1	1	2	3	1	41
16	6	15	8	7	11	13	27	5	326
17	6	13	7	6	10	11	23	4	283
18	9	21	11	10	15	18	37	7	450
19	10	22	11	11	16	19	40	7	481
20	41	97	49	45	71	83	172	32	2,076
21	3	8	4	4	6	7	14	3	172
22	30	70	36	33	52	60	125	23	1,512
23	18	43	22	20	32	37	77	14	927
24	3	7	4	3	5	6	13	2	153
25	14	33	17	16	25	29	59	11	716
26	19	46	23	21	34	39	81	15	978
27	6	14	7	6	10	12	24	5	295
28	7	17	8	8	12	14	29	5	354
29	2	4	2	2	3	3	7	1	80
30	11	25	13	12	18	21	44	8	530
31	29	68	35	32	50	58	121	23	1,462
32	60	142	72	66	104	121	252	47	3,038
33	7	17	9	8	13	15	31	6	369
34	19	44	23	21	33	38	79	15	950
Grand Total	588	1,378	703	647	1,014	1,182	2,451	455	29,562

Table C-22

1975 U.S. TO CANADA FORECAST
AIR PLUS SURFACE CARGO VALUED GREATER THAN $1.00 PER POUND
(Short Tons)

	CMA										
SMSA	1	2	3	4	5	6	7	8	9	10	11
1	142	30	211	172	1,413	238	248	106	116	273	1,199
2	70	15	104	85	699	118	123	53	57	135	593
3	34	7	51	42	341	57	60	26	28	66	289
4	12	3	19	15	124	21	22	9	10	24	105
5	2	0	3	2	19	3	3	1	2	4	16
6	1	0	1	1	6	1	1	0	1	1	5
7	207	44	306	251	2,057	347	360	154	169	397	1,745
8	673	143	996	815	6,690	1,128	1,172	502	549	1,290	5,674
9	21	4	31	25	206	35	36	15	17	40	175
10	91	19	134	110	903	152	158	68	74	174	766
11	191	41	283	231	1,898	320	333	143	156	366	1,610
12	1,740	369	2,578	2,110	17,311	2,919	3,033	1,300	1,421	3,339	14,683
13	546	116	809	662	5,433	916	952	408	446	1,048	4,608
14	133	28	197	161	1,323	223	232	99	109	255	1,122
15	30	6	45	37	300	51	53	23	25	58	255
16	238	50	352	288	2,364	399	414	177	194	456	2,005
17	206	44	305	250	2,050	346	359	154	168	395	1,739
18	328	70	486	398	3,262	550	572	245	268	629	2,767
19	351	74	519	425	3,488	588	611	262	286	673	2,958
20	1,514	321	2,243	1,835	15,059	2,540	2,639	1,131	1,236	2,904	12,772
21	125	27	186	152	1,246	210	218	94	102	240	1,057
22	1,103	234	1,634	1,337	10,971	1,850	1,922	824	900	2,116	9,305
23	676	143	1,002	819	6,724	1,134	1,178	505	552	1,297	5,703
24	112	24	166	136	1,113	188	195	84	91	215	944
25	522	111	774	633	5,195	876	910	390	426	1,002	4,406
26	713	151	1,057	865	7,095	1,197	1,243	533	582	1,368	6,018
27	215	46	319	261	2,143	361	375	161	176	413	1,817
28	258	55	383	313	2,570	433	450	193	211	496	2,179
29	59	12	87	71	583	98	102	44	48	113	495
30	387	82	573	469	3,846	649	674	289	316	742	3,262
31	1,066	226	1,580	1,293	10,608	1,789	1,859	797	871	2,046	8,998
32	2,216	470	3,284	2,687	22,044	3,718	3,863	1,655	1,809	4,251	18,697
33	269	57	399	326	2,677	451	469	201	220	516	2,270
34	693	147	1,027	840	6,895	1,163	1,208	518	566	1,330	5,849
Grand Total	21,562	4,576	31,948	26,139	214,483	36,172	37,581	16,106	17,602	41,365	181,919

Table C-22, continued

SMSA	CMA 12	13	14	15	16	17	18	19	Total
1	115	270	138	127	199	232	481	89	5,800
2	57	134	68	63	98	115	238	44	2,869
3	28	65	33	31	48	56	116	22	1,399
4	10	24	12	11	17	20	42	8	510
5	2	4	2	2	3	3	7	1	79
6	1	1	1	1	1	1	2	0	26
7	168	393	201	185	289	338	700	130	8,440
8	546	1,279	653	601	942	1,098	2,276	423	27,451
9	17	39	20	19	29	34	70	13	845
10	74	173	88	81	127	148	307	57	3,705
11	155	363	185	171	267	312	646	120	7,789
12	1,414	3,310	1,691	1,556	2,436	2,841	5,889	1,094	71,033
13	444	1,039	531	488	765	892	1,848	343	22,293
14	108	253	129	119	186	217	450	84	5,430
15	25	57	29	27	42	49	102	19	1,232
16	193	452	231	212	333	388	804	149	9,699
17	167	392	200	184	289	337	698	130	8,414
18	266	624	319	293	459	535	1,110	206	13,386
19	285	667	341	313	491	572	1,186	220	14,311
20	1,230	2,880	1,471	1,353	2,119	2,472	5,123	952	61,792
21	102	238	122	112	175	205	424	79	5,113
22	896	2,098	1,071	986	1,544	1,801	3,732	693	45,017
23	549	1,286	657	604	946	1,104	2,287	425	27,591
24	91	213	109	100	157	183	379	70	4,568
25	424	993	507	467	731	853	1,767	328	21,316
26	579	1,357	693	638	999	1,165	2,414	448	29,114
27	175	410	209	193	302	352	729	135	8,792
28	210	491	251	231	362	422	874	162	10,544
29	48	112	57	52	82	96	198	37	2,394
30	314	735	376	346	541	631	1,308	243	15,780
31	866	2,028	1,036	953	1,493	1,741	3,609	670	43,530
32	1,800	4,215	2,153	1,981	3,103	3,618	7,499	1,393	90,457
33	219	512	261	241	377	439	911	169	10,984
34	563	1,319	673	620	971	1,132	2,346	436	28,295
Grand Total	17,514	41,013	20,946	19,274	30,188	35,204	72,961	13,553	880,106

Table C-23

1980 U.S. TO CANADA FORECAST
AIR PLUS SURFACE CARGO VALUED GREATER THAN $1.00 PER POUND
(Short Tons)

SMSA	CMA 1	2	3	4	5	6	7	8	9	10	11
1	197	42	291	238	1,955	330	342	147	160	377	1,658
2	97	21	144	118	967	163	169	73	79	186	820
3	47	10	70	57	472	80	83	35	39	91	400
4	17	4	26	21	172	29	30	13	14	33	146
5	3	1	4	3	27	5	5	2	2	5	23
6	1	0	1	1	9	2	2	1	1	2	8
7	286	61	424	347	2,844	480	498	214	233	549	2,413
8	930	197	1,378	1,128	9,252	1,560	1,621	695	759	1,784	7,847
9	29	6	42	35	285	48	50	21	23	55	241
10	126	27	186	152	1,249	211	219	94	102	241	1,059
11	264	56	391	320	2,625	443	460	197	215	506	2,227
12	2,407	511	3,566	2,918	23,940	4,037	4,195	1,798	1,965	4,617	20,305
13	755	160	1,119	916	7,513	1,267	1,316	564	617	1,449	6,373
14	184	39	273	223	1,830	309	321	137	150	353	1,552
15	42	9	62	51	415	70	73	31	34	80	352
16	329	70	487	398	3,269	551	573	245	268	630	2,772
17	285	61	422	346	2,836	478	497	213	233	547	2,405
18	454	96	672	550	4,512	761	791	339	370	870	3,827
19	485	103	718	588	4,823	813	845	362	396	930	4,091
20	2,094	444	3,102	2,538	20,826	3,512	3,649	1,564	1,709	4,016	17,664
21	173	37	257	210	1,723	291	302	129	141	332	1,462
22	1,525	324	2,260	1,849	15,172	2,559	2,658	1,139	1,245	2,926	12,869
23	935	198	1,385	1,133	9,299	1,568	1,629	698	763	1,793	7,887
24	155	33	229	188	1,539	260	270	116	126	297	1,306
25	722	153	1,070	876	7,184	1,212	1,259	539	590	1,386	6,093
26	986	209	1,462	1,196	9,812	1,655	1,719	733	805	1,892	8,322
27	298	63	441	361	2,963	500	519	223	243	571	2,513
28	357	76	529	433	3,553	599	623	267	292	685	3,014
29	81	17	120	98	807	136	141	61	66	156	684
30	535	113	792	648	5,318	897	932	399	436	1,026	4,511
31	1,475	313	2,185	1,788	14,671	2,474	2,571	1,102	1,204	2,829	12,443
32	3,065	651	4,541	3,715	30,486	5,142	5,342	2,289	2,502	5,880	25,858
33	372	79	551	451	3,702	624	649	278	304	714	3,140
34	959	203	1,420	1,162	9,536	1,608	1,671	716	783	1,839	8,088
Grand Total	29,820	6,329	44,182	36,149	296,617	50,024	51,972	22,273	24,342	57,205	251,583

Table C-23, continued

SMSA	CMA 12	13	14	15	16	17	18	19	Total
1	160	374	191	176	275	321	665	124	8,021
2	79	185	94	87	136	159	329	61	3,968
3	39	90	46	42	66	77	160	30	1,935
4	14	33	17	15	24	28	59	11	706
5	2	5	3	2	4	4	9	2	110
6	1	2	1	1	1	1	3	1	37
7	232	544	278	256	400	467	968	180	11,672
8	755	1,769	904	831	1,302	1,519	3,147	585	37,963
9	23	54	28	26	40	47	97	18	1,168
10	102	239	122	112	176	205	425	79	5,124
11	214	502	256	236	369	431	893	166	10,772
12	1,955	4,578	2,338	2,151	3,369	3,929	8,144	1,513	98,236
13	614	1,437	734	675	1,057	1,233	2,556	475	30,830
14	149	350	179	164	258	300	623	116	7,510
15	34	79	41	37	58	68	141	26	1,704
16	267	625	319	294	460	537	1,112	207	13,413
17	232	542	277	255	399	465	965	179	11,636
18	368	863	441	405	635	741	1,535	285	18,513
19	394	922	471	433	679	792	1,641	305	19,791
20	1,701	3,982	2,034	1,871	2,931	3,418	7,084	1,316	85,456
21	141	330	168	155	243	283	586	109	7,072
22	1,239	2,901	1,482	1,363	2,135	2,490	5,161	959	62,257
23	759	1,778	908	836	1,309	1,526	3,163	588	38,157
24	126	294	150	138	217	253	524	97	6,317
25	587	1,374	702	646	1,011	1,179	2,444	454	29,479
26	801	1,876	958	882	1,381	1,611	3,338	620	40,263
27	242	567	289	266	417	486	1,008	187	12,159
28	290	679	347	319	500	583	1,209	225	14,581
29	66	154	79	73	114	132	274	51	3,311
30	434	1,017	519	478	749	873	1,809	336	21,823
31	1,198	2,805	1,433	1,318	2,065	2,408	4,991	927	60,200
32	2,489	5,830	2,977	2,740	4,291	5,004	10,371	1,927	125,098
33	302	708	362	333	521	608	1,259	234	15,190
34	779	1,824	931	857	1,342	1,565	3,244	603	39,131
Grand Total	24,221	56,718	28,968	26,655	41,748	48,685	100,901	18,743	1,217,135

Table C-24

1985 U.S. TO CANADA FORECAST
AIR PLUS SURFACE CARGO VALUED GREATER THAN $1.00 PER POUND
(Short Tons)

SMSA	CMA 1	2	3	4	5	6	7	8	9	10	11
1	272	58	403	329	2,703	456	474	203	222	522	2,293
2	134	29	199	163	1,337	226	234	100	110	258	1,134
3	66	14	97	80	652	110	114	49	54	126	553
4	24	5	35	29	238	40	42	18	20	46	202
5	4	1	5	4	37	6	6	3	3	7	31
6	1	0	2	1	12	2	2	1	1	2	10
7	396	84	586	479	3,934	663	689	295	323	759	3,337
8	1,286	273	1,906	1,559	12,795	2,158	2,242	961	1,050	2,468	10,853
9	40	8	59	48	394	66	69	30	32	76	334
10	174	37	257	210	1,727	291	303	130	142	333	1,465
11	365	77	541	442	3,631	612	636	273	298	700	3,079
12	3,329	706	4,932	4,035	33,110	5,584	5,801	2,486	2,717	6,386	28,083
13	1,045	222	1,548	1,266	10,391	1,752	1,821	780	853	2,004	8,813
14	254	54	377	308	2,531	427	443	190	208	488	2,147
15	58	12	86	70	574	97	101	43	47	111	487
16	454	96	673	551	4,521	762	792	339	371	872	3,834
17	394	84	584	478	3,922	661	687	294	322	756	3,326
18	627	133	929	760	6,240	1,052	1,093	469	512	1,203	5,292
19	671	142	994	813	6,670	1,125	1,169	501	547	1,286	5,658
20	2,896	615	4,290	3,510	28,802	4,858	5,047	2,163	2,364	5,555	24,429
21	240	51	355	290	2,383	403	418	179	196	460	2,022
22	2,110	448	3,126	2,557	20,983	3,539	3,677	1,576	1,722	4,407	17,797
23	1,293	274	1,916	1,567	12,861	2,169	2,253	966	1,055	2,480	10,908
24	214	45	317	259	2,129	359	373	160	175	411	1,806
25	999	212	1,480	1,211	9,936	1,676	1,741	746	815	1,916	8,427
26	1,364	290	2,021	1,654	13,570	2,289	2,378	1,019	1,114	2,617	11,510
27	412	87	610	499	4,098	691	718	308	336	790	3,476
28	494	105	732	599	4,914	829	861	369	403	948	4,168
29	112	24	166	136	1,116	188	196	84	92	215	946
30	739	157	1,096	896	7,355	1,240	1,289	552	604	1,419	6,239
31	2,040	433	3,022	2,473	20,290	3,422	3,555	1,524	1,665	3,913	17,209
32	4,239	900	6,280	5,139	42,164	7,111	7,388	3,166	3,460	8,132	35,762
33	515	109	763	624	5,120	863	897	384	420	987	4,342
34	1,326	218	1,965	1,607	13,189	2,224	2,311	990	1,082	2,544	11,187
Grand Total	41,242	8,753	61,105	49,995	410,232	69,185	71,879	30,805	33,667	79,117	347,948

Table C-24, continued

SMSA	CMA 12	13	14	15	16	17	18	19	Total
1	220	517	264	243	380	444	920	171	11,093
2	109	256	131	120	188	220	455	85	5,488
3	53	125	64	59	92	107	222	41	2,677
4	19	45	23	21	33	39	81	15	976
5	3	7	4	3	5	6	13	2	151
6	1	2	1	1	2	2	4	1	50
7	321	752	384	354	554	646	1,338	249	16,143
8	1,045	2,447	1,250	1,150	1,801	2,100	4,353	809	52,504
9	32	75	38	35	55	65	134	25	1,616
10	141	330	169	155	243	283	588	109	7,087
11	296	694	355	326	511	596	1,235	229	14,898
12	2,704	6,331	3,234	2,975	4,660	5,435	11,263	2,092	135,863
13	849	1,987	1,015	934	1,463	1,706	3,535	657	42,639
14	207	484	247	227	356	415	861	160	10,386
15	47		56	52	81	94	195	36	2,357
16	369	864	441	406	636	742	1,538	286	18,550
17	320	750	383	352	552	644	1,334	248	16,093
18	510	1,193	609	561	878	1,024	2,123	394	25,604
19	545	1,275	651	599	939	1,095	2,269	422	27,371
20	2,352	5,508	2,813	2,588	4,054	4,728	9,798	1,822	118,188
21	195	456	233	214	335	391	811	151	9,780
22	1,713	4,012	2,049	1,886	2,953	3,444	7,138	1,326	86,103
23	1,050	2,459	1,256	1,156	1,810	2,111	4,375	813	52,773
24	174	407	208	191	300	349	724	135	8,737
25	811	1,900	970	893	1,398	1,631	3,380	628	40,771
26	1,108	2,595	1,325	1,220	1,910	2,227	4,616	858	55,685
27	335	784	400	368	577	673	1,394	259	16,817
28	401	940	480	442	692	807	1,672	311	20,166
29	91	213	109	100	157	183	380	71	4,579
30	601	1,406	718	661	1,035	1,207	2,502	465	30,182
31	1,657	3,880	1,982	1,823	2,856	3,330	6,902	1,282	83,258
32	3,443	8,062	4,118	3,789	5,934	6,921	14,343	2,664	173,014
33	418	979	500	460	721	840	1,742	324	21,008
34	1,077	2,522	1,288	1,185	1,856	2,165	4,487	833	54,120
Grand Total	33,499	78,444	40,064	36,865	57,739	67,334	139,540	25,023	1,682,245

Table C-25

SCALING FACTORS

Air Plus Surface Cargo Valued Greater Than $/lb.	Services Canada to Europe	Europe to Canada	U.S. to Europe	Europe to U.S.	Canada to U.S.	U.S. to Canada
1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.50	0.45	0.72	0.59	0.63	0.24	0.45
2.00	0.29	0.57	0.47	0.44	0.20	0.24
3.00	0.16	0.51	0.36	0.36	0.06	0.12
4.00	0.13	0.49	0.34	0.33	0.05	0.09
5.00	0.10	0.49	0.32	0.32	0.05	0.08
Air cargo only	0.07	0.49	0.30	0.32	0.05	0.05

Table C-26

MONTREAL DOMESTIC CARGO
(Thousand Short Tons)

	1975				1980				1985			
	Outbound		Inbound		Outbound		Inbound		Outbound		Inbound	
	Tons	Cum. Tons	Tons	Cum. Tons	Tons	Cum. Tons	Tons	Cum. Tons	Tons	Cum. Tons	Tons	Cum. Tons
Air cargo only	42	42	27	27	54	54	36	36	70	70	46	46
Surface > $5	25	67	13	40	32	86	17	53	42	112	22	68
Surface $4-$5	13	80	7	47	17	103	8	61	22	134	11	79
Surface $3-$4	27	107	14	61	36	139	19	80	46	180	24	103
Surface $2-$3	156	263	83	144	203	342	108	188	264	426	141	244
Surface $1.50-$2	198	461	107	251	257	599	139	327	335	761	180	424
Surface $1-$1.50	714	1,175	384	635	929	1,528	499	826	1,208	1,969	649	1,073
Surface 0-$1	52,200	53,375	28,010	28,645	67,898	69,426	36,434	37,260	88,320	90,289	47,392	48,465

Appendix D

AIR CARGO FORECAST

Appendix D

AIR CARGO FORECAST

Table D-1 presents the air cargo growth rates for the various services analyzed. These growth rates are the result of the analysis described in the main body of the report.

Figures D-1 through D-7 superimpose the forecast of air cargo resulting from the growth rates in Table D-1 on the forecasts of the total trade. The figure for the Canada to Europe trade is presented in Figure 3 in the main body of the report. The data presented in Table 10 in the main body of the report were taken from these figures.

Table D-1

RANGES OF ANNUAL GROWTH RATES
(Per Cent)

	Low	Average	High
Canada-Europe			
1970-1975	10	15	20
1975-1985	8	10	12
Europe-Canada			
1970-1975	6	8	10
1975-1985	6	8	8
U.S.-Europe			
1970-1975	10	12	14
1975-1985	8	10	12
Europe-U.S.			
1970-1975	10	12	14
1975-1985	8	10	12
Canada-U.S.			
1970-1975	8	12	15
1975-1985	8	12	15
U.S.-Canada			
1970-1975	10	12	15
1975-1985	8	10	12
Canadian domestic			
1970-1975	12	15	18
1975-1985	8	10	12

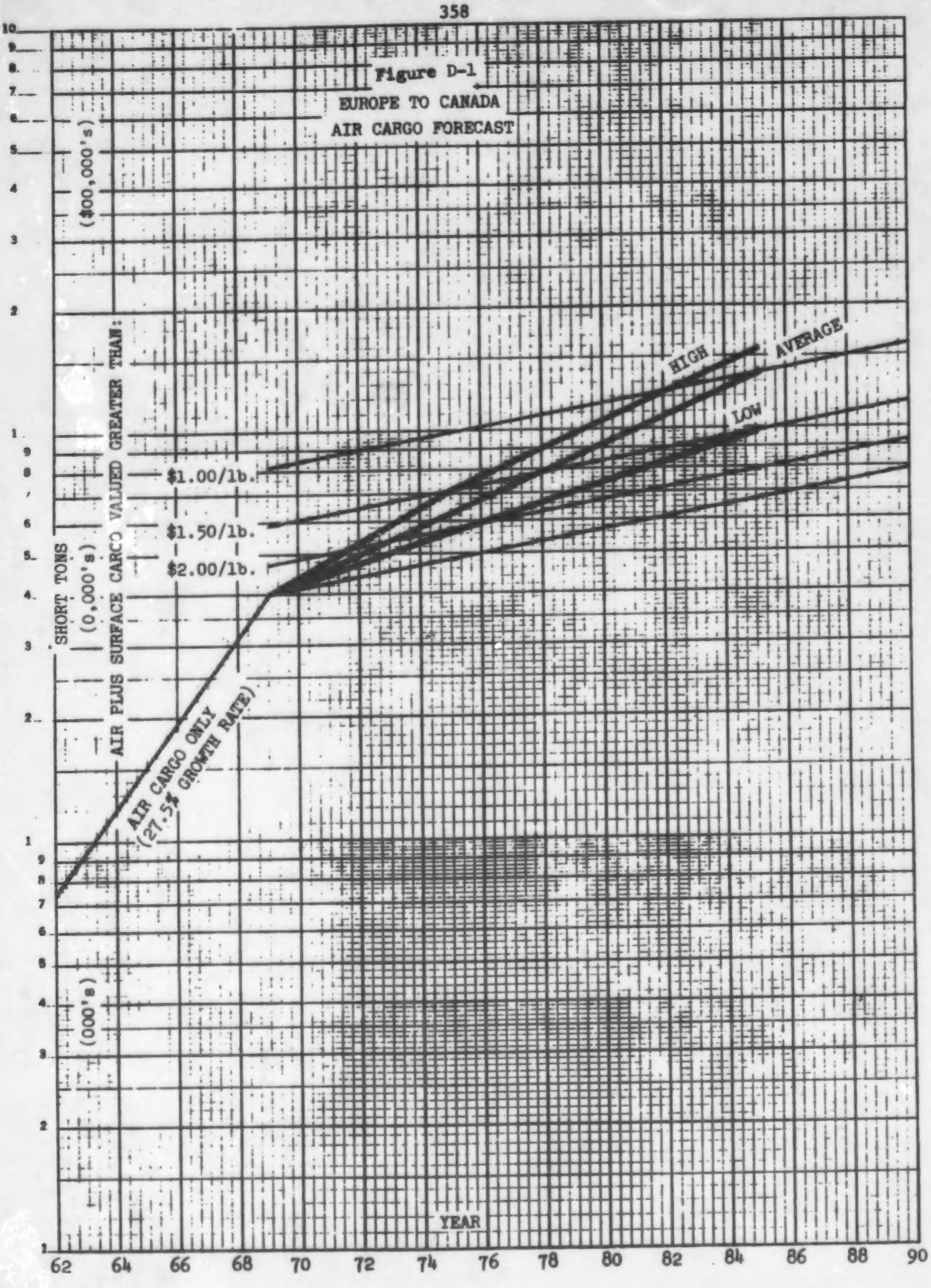


Figure D-1

EUROPE TO CANADA

AIR CARGO FORECAST

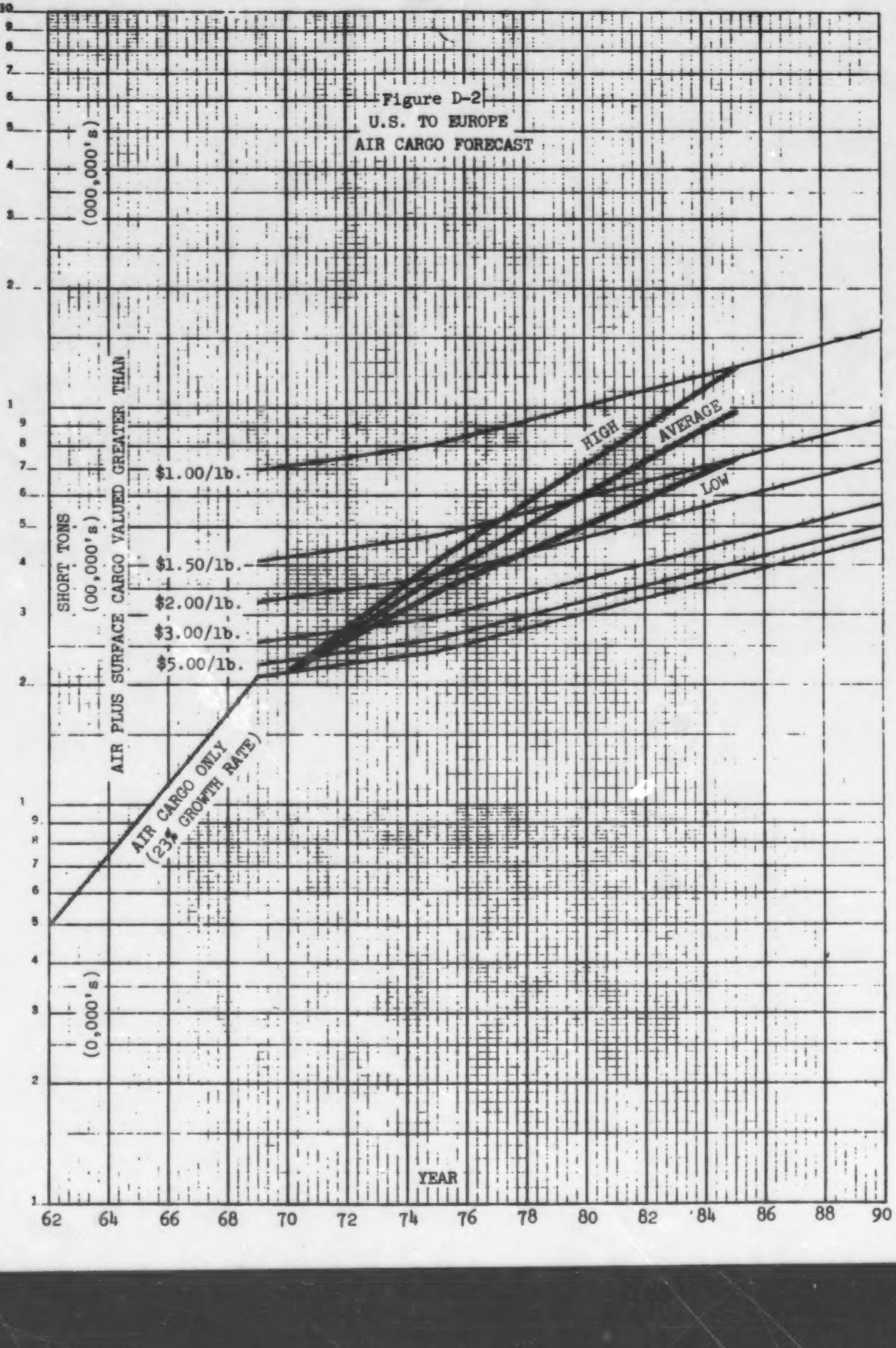


Figure D-2
U.S. TO EUROPE
AIR CARGO FORECAST

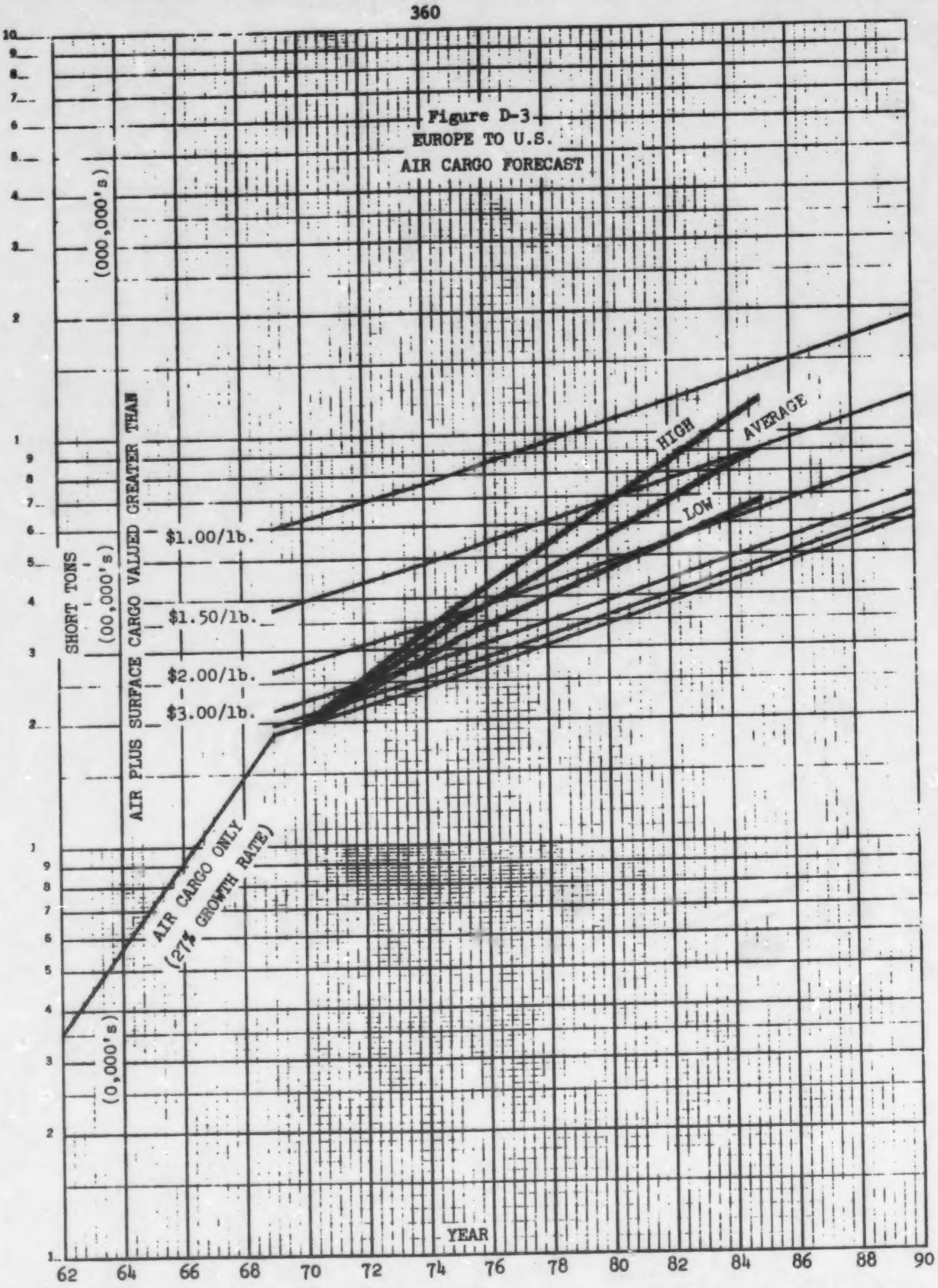


Figure D-3
EUROPE TO U.S.
AIR CARGO FORECAST

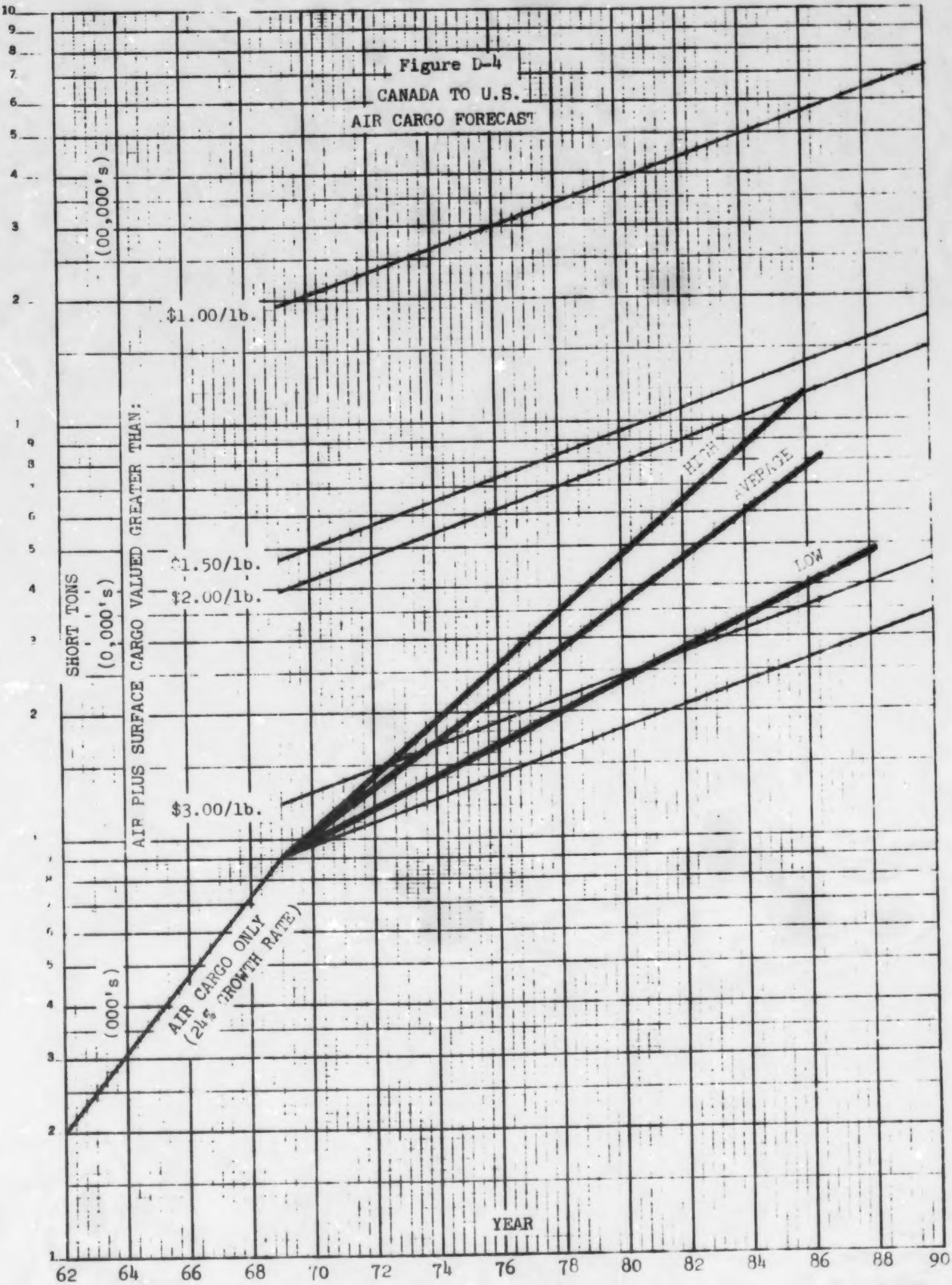


Figure D-4

CANADA TO U.S.

AIR CARGO FORECAST

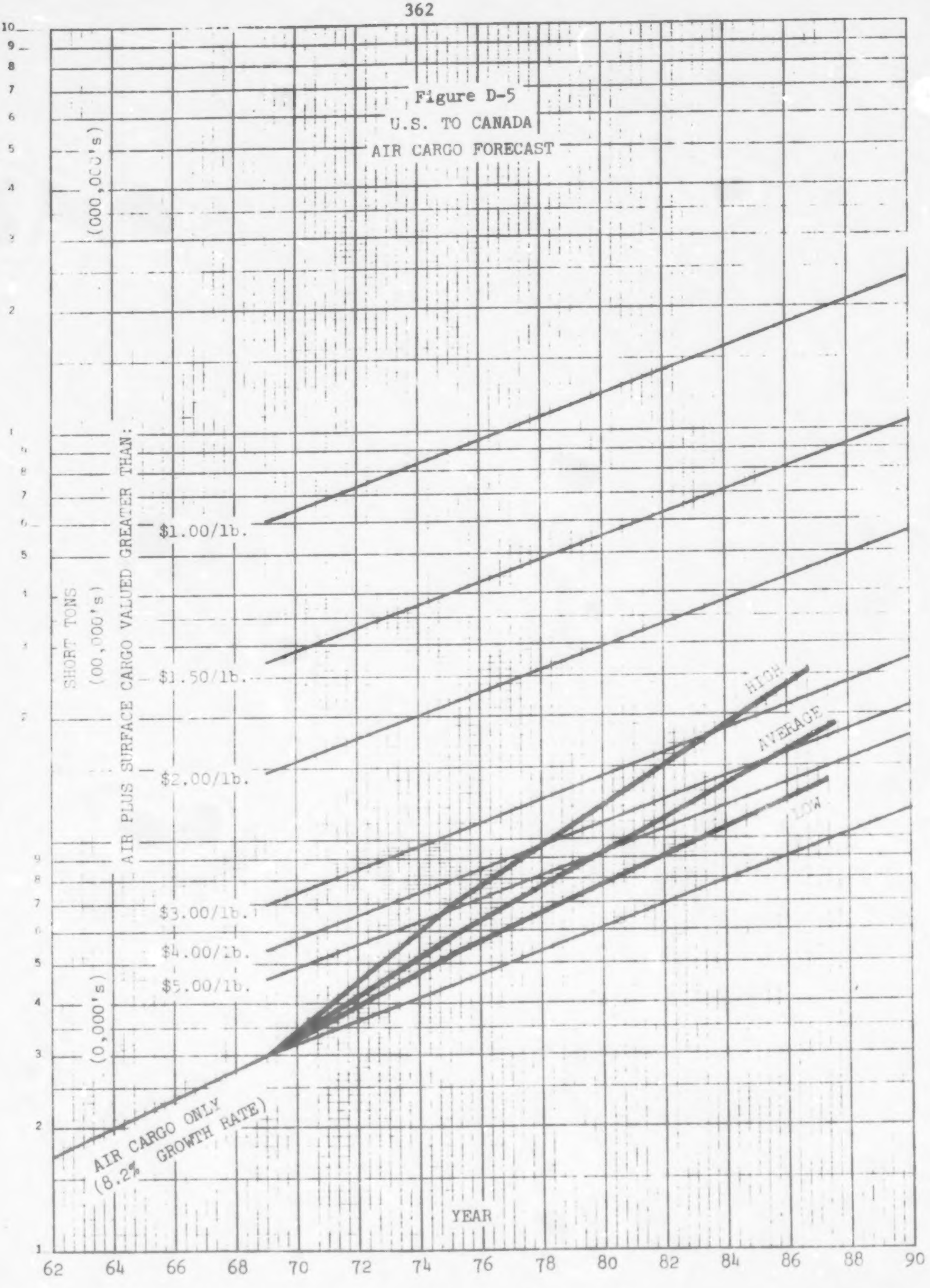


Figure D-5
U.S. TO CANADA
AIR CARGO FORECAST

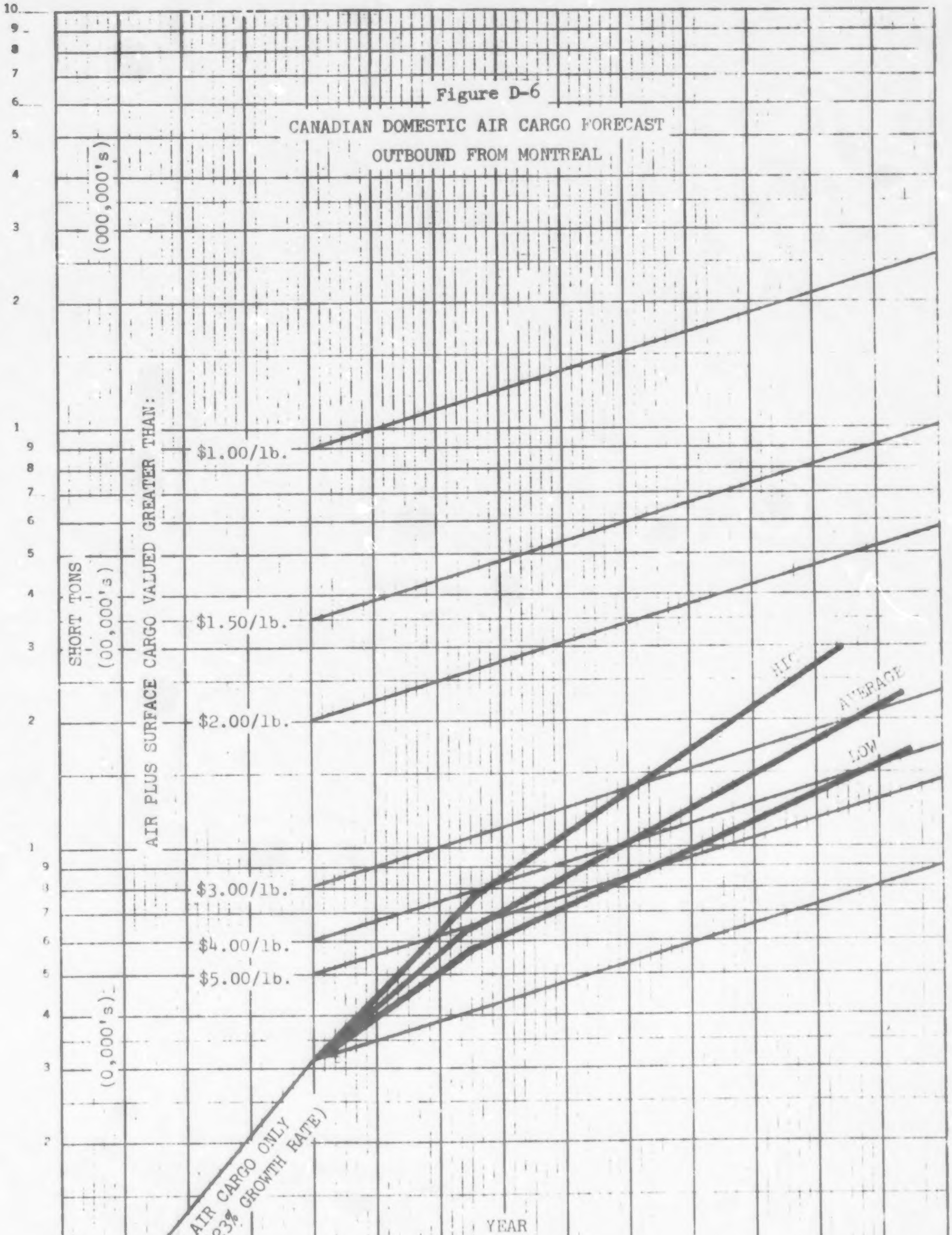


Figure D-6

CANADIAN DOMESTIC AIR CARGO FORECAST

OUTBOUND FROM MONTREAL

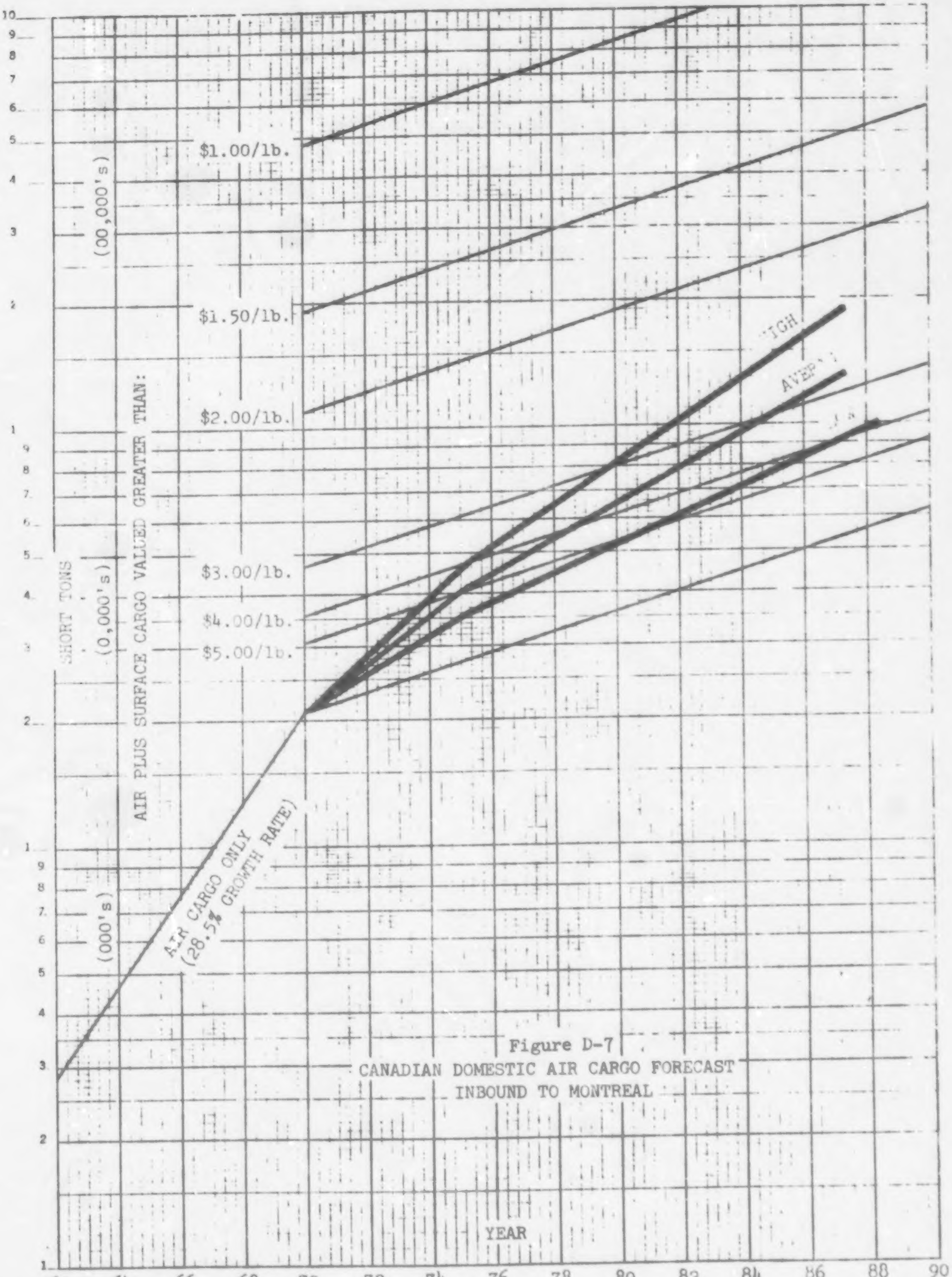


Figure D-7
CANADIAN DOMESTIC AIR CARGO FORECAST
INBOUND TO MONTREAL

Appendix E

CARGO CAPACITY OF PASSENGER AIRCRAFT

Appendix E

CARGO CAPACITY OF PASSENGER AIRCRAFT

Figure E-1 shows the past growth of North Atlantic passenger traffic and capacity for scheduled airlines, the ICAO forecast (1970)* of traffic and capacity and our estimated growth rate of 13 per cent per year. Superimposed on the graph is the estimated passenger capacity of the wide-body aircraft in North Atlantic service. The estimate of wide-body aircraft and capacity, given in Table E-1 is slightly less than that of ICAO. The ICAO report assumes that Concordes will enter service in 1974 and the Boeing SST in 1978. While we are less optimistic about the supersonic jets, we have not increased the size of the wide-body fleet to make up for any loss of estimated supersonic capacity. Given the present financial difficulties of airlines, we feel that new orders for wide-body jets will not be placed by North Atlantic carriers until the uncertainties of service by supersonic aircraft are clarified (perhaps 1975).

Below we give the present** and 1975 estimated market shares of the major passenger origins and destinations of North Atlantic passengers. Other East Coast includes Boston, Philadelphia, and Washington/Baltimore.

Center	New York	Other East Coast	West Coast	Other U.S.	Montreal	Other Canada
1970	71.2%		4.9%	8.1%	15.8%	
1975 (Est.)	55%	10%	7%	12%	14%	2%

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* ICAO Ten-Year North Atlantic Air Traffic Forecast, T 17/1.11302.

** IATA-World Air Transport Statistics, November 15, 1970.

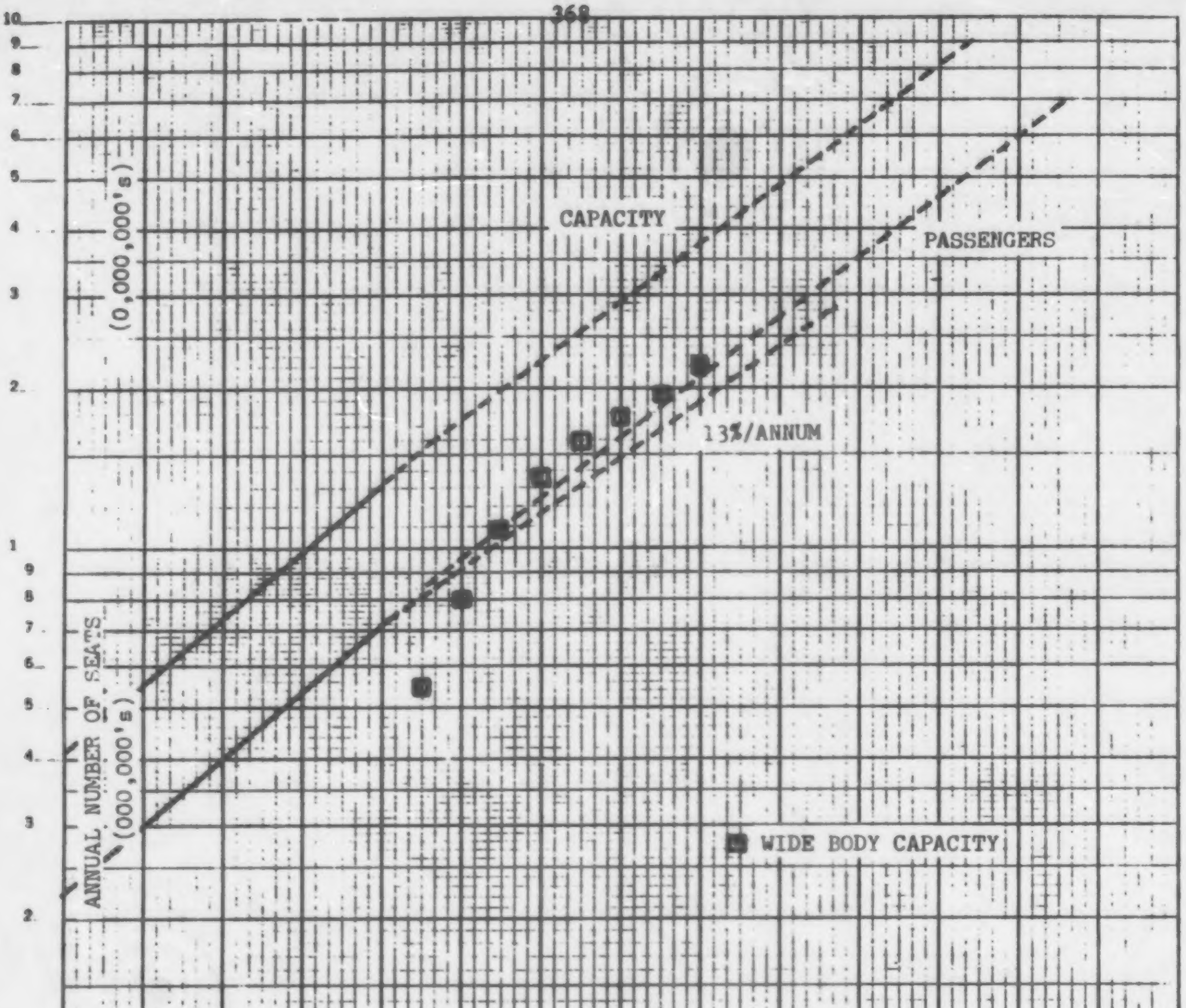

Figure E-1
TOTAL NORTH ATLANTIC
PASSENGERS AND CAPACITY

Table E-1

WIDE-BODY LONG-RANGE AIRCRAFT IN NORTH ATLANTIC SERVICE

			Annual Capacity			
			Passengers (000)		Cargo (000 tonnes)	
Year	747	DC-10	747	DC-10	747	DC-10
1971	30	-	5,450	-	280	-
1972	44	-	8,000	-	410	-
1973	55	5	10,000	800	510	36
1974	60	15	10,900	2,350	560	110
1975	65	25	11,800	3,920	610	180
1976	70	30	12,700	4,700	655	220
1977	75	40	13,600	6,180	700	[illegible]
1978	80	45	14,500	7,050	745	325

Using ICAO definition 5 R/T/week 747-350 seats DC-10 300 seats
747-18 tonnes DC-10 14 tonnes

Other U.S. includes Chicago, Detroit, Houston, Dallas/Fort Worth and other inland centers. Other Canada includes Vancouver and Toronto and other centers on flights not routed via Montreal. We anticipate a reduction in New York's share as other cities generate sufficient traffic to justify direct flights.

Charter flights by IATA members carried 816,000 passengers in 1970 (scheduled flights carried 7,200,000 passengers) and we estimate that nonscheduled carriers carried about 1,000,000 to 1,500,000 passengers in the same year. Because nonscheduled carriers do not carry cargo in passenger flights we have excluded them from further consideration. In addition, because charter cargo flights by both scheduled and nonscheduled airlines carried less than 3 per cent of North Atlantic cargo, we are excluding these flights from our analysis.

On the basis of market size and importance we have tried to assign wide-body aircraft to major market centers with special emphasis on Chicago, Detroit and Montreal. The forecast assignments are given in Table E-2. Note that in the period 1971-1978 New York's share of wide-body aircraft decreases from 70 per cent to 60 per cent, while Montreal's share increases from 10 per cent to 13 per cent. We estimate Chicago's share at about two thirds that of Montreal in 1978 and about half in 1975. The numbers are meant to be indicative estimates rather than precise forecasts.

Table E-2

NORTH ATLANTIC WIDE-BODY AIRCRAFT ASSIGNMENTS TO NORTH AMERICAN CITIES

Year	Total		New York		Chicago		Detroit		Montreal		Other	
	747	DC-10	747	DC-10	747	DC-10	747	DC-10	747	DC-10	747	DC-10
1971	30	-	21	-	2	-	-	-	3	-	4	-
1972	44	-	30	-	3	-	-	-	4	-	7	-
1973	55	5	38	2	4	2	1	-	5	1	7	-
1974	60	15	43	5	4	3	1	-	6	2	6	5
1975	65	25	48	9	4	3	1	1	7	6	5	6
1976	70	30	52	10	5	4	1	1	7	7	5	8
1977	75	40	54	15	6	5	1	2	8	8	6	10
1978	80	45	59	16	6	5	1	3	8	9	6	12

For our estimates of passenger and cargo capacity of wide-body aircraft we follow the ICAO 1970 forecast (op cit). Wide-body and conventional passenger aircraft will perform 5 round trips per week with the following capacities:

	747	DC-10	Conventional Jets
Passengers	350	300	150
Cargo (short tons)	20	15	5.5

Given the 1975 distribution of wide-body aircraft and the market shares of major cities, we have the aircraft assignments and per cent of capacity in conventional jets as given in Table E-3. The passenger aircraft in North Atlantic service in 1975 will have an effective capacity more than half again greater than the total cargo carried in 1970. New York's effective capacity in passenger aircraft alone will be almost equal to the total U.S. air cargo carried in 1970, and Montreal's effective belly capacity in 1975 will exceed the total weight of Canadian North Atlantic air imports in 1970. We have been extremely conservative in forecasting Detroit's growth as a passenger center; we could easily be off by a factor of two. At the present time Detroit, the fifth largest domestic air freight hub, is exceeded in cargo originations only by New York/Newark, Chicago, Los Angeles and San Francisco. Table E-4* shows the ranking of U.S. air hubs in terms of cargo, express and mail originations.

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* "The Washington-Baltimore Regional Air Freight Transportation System" D.H. Reber and J. W. Dwyer, Analytic Services, Inc., Falls Church, Virginia, March 1970.

Table E-3

ESTIMATED 1975 AIRCRAFT ASSIGNMENTS AND SHARES OF CAPACITY NORTH ATLANTIC SERVICE

City	New York	Montreal	Chicago	Detroit	All Others
747	48	7	4	1	5
DC-10	9	6	3	1	6
707/DC-8	46	20	19	5	29
Total Aircraft	103	33	26	7	40
Per cent passenger capacity conventional	26	42	52	50	55
Per cent passenger capacity wide body	74	58	48	50	45
Effective one-way belly cargo capacity (000 short tons) @ 50% load factor	176	44	30	8	45

Table E-4

LARGE CARGO HUBS IN 1968

	Freight		Express		Mail		Total Cargo	
Hub City*	Weight**	Rank	Weight**	Rank	Weight**	Rank	Weight**	Rank
Chicago	329.75	1	61.41	1	186.54	1	577.70	1
New York	300.11	2	20.58	4	118.92	2	439.60	2
Los Angeles, Burbank, and Long Beach	262.60	3	12.61	8	83.71	3	358.92	3
San Francisco/ Oakland	218.27	4	9.02	12	73.21	4	300.50	4
Detroit/Ann Arbor	155.49	5	26.43	2	40.56	9	222.48	5
Newark	111.73	6	12.67	6	47.33	8	171.72	6
Atlanta	72.87	11	24.59	3	58.73	6	156.18	7
Dallas	84.25	9	12.66	7	52.42	7	149.34	8
Philadelphia/ Camden	94.36	7	8.84	13	35.39	10	138.60	9
Boston	86.45	8	10.48	10	26.94	15	123.89	10
Cleveland	83.24	10	12.99	5	21.59	19	117.83	11
Washington	35.44	18	12.30	9	58.82	5	106.57	12
Minneapolis/ St. Paul	50.07	12	8.74	14	33.26	11	92.08	13
Denver	41.78	14	4.25	24	28.83	13	74.87	14
St. Louis	37.28	16	8.15	15	29.28	12	74.71	15
Kansas City	31.03	20	7.23	16	28.67	14	68.93	16
Miami/ Ft. Lauderdale	44.44	13	4.64	21	16.86	22	65.93	17
Seattle/Tacoma	38.32	15	(1.86)	--	21.63	18	61.81	18
Pittsburgh	(27.58)	--	9.44	11	22.28	17	59.30	19
Indianapolis	35.44	19	5.70	18	(12.79)	--	53.93	20
Houston	31.63	21	(3.14)	--	17.20	21	51.97	21
Baltimore	(22.76)	--	(3.72)	--	24.82	16	51.31	22
Hartford and Springfield/ Westfield	35.85	17	(3.27)	--	(10.89)	--	50.01	23
Cincinnati	(24.23)	--	6.66	17	14.83	23	(45.72)	--
Memphis	(23.42)	--	5.32	19	(12.44)	--	(41.18)	--
Dayton	(26.95)	--	4.52	22	(6.99)	--	(38.47)	--
Buffalo	(21.23)	--	4.80	20	(9.53)	--	(35.57)	--
Milwaukee	(17.58)	--	4.48	23	(11.37)	--	(33.43)	--
Salt Lake City	(13.13)	--	(1.02)	--	18.73	20	(32.89)	--

* Listed in order of descending total cargo weight.

** Millions of pounds.

() Hub originates less than 1 per cent of total weight of that cargo category and, therefore, is not a large hub for that category.

Appendix F

AIR CARGO TERMINAL COST MODEL

Appendix F

AIR CARGO TERMINAL COST MODEL

This appendix describes the development of the air cargo terminal cost model that was used to estimate the terminal costs discussed in Chapter III. The model is in the form of sequential equations with table lookups for the various exogenous parameters. The first six equations determine the costs of separate items (for example, construction, equipment). The costs of the separate items are combined in Equation (7) to determine the cost per ton for the individual option being analyzed. Simultaneously with the discussion of the individual cost items in the model, we will illustrate the use of the model with a specific example.

The arguments for entering the model are the values of T (annual throughput), L (location) and i (transfer type).

The values for annual throughputs we used were arbitrarily selected to cover a wide range. They were 5,000, 25,000, 37,500, 50,000 and 100,000 short tons. The locations analyzed were New York and Montreal. The transfer types involve combinations of assumptions as to the dispersal of the cargo in and out of the terminal and the level of cargo handling mechanization within the terminal itself.

The specific example we are using for illustrative purposes consists of the following arguments:

T = 25,000 short tons

L = Montreal

i = Option 7

The option 7 transfer type refers to a 48 per cent inbound ratio, assumes that 50 per cent of the cargo is dispersed by truck, 50 per cent of the cargo moves on pallets and the terminal is not highly mechanized. A complete description of the transfer options will be presented below.

All costs were inflated from the known years costs to 1974 using the compound annual rates shown below. The equations are:

Terminal building area (square feet)

$$S = 5.48T \times K_T \times C_i\left(\frac{I_i}{6.5} + \frac{(1-I_i)}{9.5}\right) + \frac{1}{40} \tag{1}$$

Annual land rent ($)

$$R = r_L\ 50{,}000 \times A_T \times Y_L + S + 5.48T \times K_T \times M_i\left(\frac{I_i}{6.5} + \frac{(1-I_i)}{9.5}\right) \tag{2}$$

Annual fixed facility costs ($)

$$C = N_c\ C_{Ls} + A_T \times 50{,}000 \times 2.50 \times Y_L + P_L \times 5.48 \times T \times K_T \times M_i\left(\frac{I_i}{6.5} + \frac{(1-I_i)}{9.5}\right) \tag{3}$$

Annual equipment costs ($)

$$E = \left(N_e \times \left(\frac{T \times K_T}{365}\right) \times E_i \times E_L\right) + N_L \times A_T \times \$91{,}000 \times 1.12^{(1-Y_L)} \tag{4}$$

Annual labor cost ($)

$$U = W_{cL} \times T \times H_i + W_{sL} \times T \times H_T \tag{5}$$

Airport tonnage charges ($)

$$D = T \times 1.275 \times (1 - Y_L) \tag{6}$$

Cost per ton ($)

$$\frac{R + C + E + U + D}{T} \qquad (7)$$

The parameters in the foregoing equations are defined in Table F-1.

Equation (1) - Terminal Building Area

The first three terms in the equation convert annual throughput in short tons to peak day throughput in pounds. The constant 5.48 is a ratio derived from dividing 2,000 pounds by 365 days and is used as a conversion factor to change annual tons to average daily pounds. K_T, from Table F-2, is a factor to estimate the peak day throughput given the average daily throughput. The factor was developed in a study by the Stuttgart Airport* where the ratios for peak day to average day throughput were given for selected throughputs at a number of German airports. The study also analyzed the cargo terminals at 15 airports around the world. The values for the parameters in the brackets in Equation (1) can be found in Table F-3. The inbound ratio, I, is based on ICAO statistical patterns of cargo flows both for New York and Montreal in 1970.** The 6.5 and 9.5 constants represent pounds per square foot of terminal space required for inbound, outbound cargo. These figures were derived from analyses made by MI of the United Air Lines and American Airlines cargo terminals at the San Francisco Airport, from the aformentioned Stuttgart report, and from comparable

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* Luftfracht - Abfertigungs Gebaude, 1968, Table 4.

** ICAO - Series AT-No. 11 - (1970 Throughput for Airports).

Table F-1

PARAMETER DEFINITION

A_T	Number of apron positions.
C	Annual costs of the fixed facilities (terminal building, apron and truck parking area), dollars.
C_i	Terminal cargo space adjustment factor.
C_{LS}	Terminal construction costs, dollars.
D	Annual tonnage charges, dollars.
E	Annual equipment costs, dollars.
E_i	Terminal equipment investment per peak day ton, dollars.
E_L	Adjustment factor for duties and installation costs of terminal equipment between New York and Montreal.
H_i	Labor productivity, man-hours per ton.
H_T	Security force productivity, man-hours per ton.
I_i	Ratio of inbound air tonnage to total air tonnage.
K_T	Ratio of peak day throughput to average day throughput.
M_i	Truck parking area adjustment factor.
N_c	Annual cost per dollar of fixed facility investment.
N_e	Annual cost per dollar of terminal equipment investment.
N_L	Annual cost per dollar of loading position investment.
P_L	Unit cost of truck parking area, dollars per square foot.

r_L	Annual unit land rent, dollars per square foot.
R	Annual land rental cost, dollars.
S	Terminal building area, square feet.
T	Annual throughput, short tons.
U	Annual labor cost, dollars.
W_{cL}	Production labor cost, dollars per man-hour.
W_{sL}	Security labor cost, dollars per man-hour.
Y_L	Dummy variable used to zero out costs that are not applicable to Montreal. Assumes a value of zero when Montreal terminals are being analyzed and a value of 1 when New York terminals are being analyzed.

Table F-2

VALUES FOR THROUGHPUT DEPENDENT PARAMETERS

	Annual Throughput (S.T.)				
	5,000	25,000	37,500	50,000	100,000
K_T	2.5	2.0	1.9	1.75	1.5
A_T	0	1	1	1	2
H_T	1.0	0.52	0.41	0.35	0.25

Table F-3

CASE DESCRIPTION AND PARAMETER VALUES

Case i	Inbound Ratio I_i %	Plane/Plane Ratio %	Palletization Ratio %	Degree of Mechanization	C_i	M_i	E_i	H_i
1	48	25	25	Low	1.0	1.5	$1,625	2.813
2	61	25				1.5		2.6879
3	48	50				1.251		2.711
4	61	50				1.251		2.558
5	48	25	50		0.750	1.125		2.226
6	61	25				1.125		2.1383
7	48	50				0.939		2.142
8	61	50				0.939		2.032
9	48	25	25	High	0.625	1.5	$3,250	2.395
10	61	25				1.5		2.265
11	48	50				1.251		2.275
12	61	50				1.251		2.112
13	48	25	50		0.500	1.125		1.914
14	61	25				1.125		1.823
15	48	50				0.939		1.818
16	61	50				0.939		1.701

truck terminal facilities in the San Francisco Bay Area. They pertain to an unmechanized facility that handles 25 per cent of the cargo on pallets. Based on this type of terminal, the C_i factor is used to adjust the cargo space required to account for the degree of palletization and/or mechanization of the terminal. The actual C_i values were derived in the following manner. Assuming that 75 per cent of the terminal space is utilized basically for palletizing, depalletizing and associated sorting, the highly mechanized terminal would reduce the required space by 50 per cent. Furthermore, prepalletized freight bypasses this area, and therefore the area required is proportional to the unpalletized throughput: in one case 75 per cent of total cargo unpalletized, and in the other case 50 per cent unpalletized, or one-third less. Thus, the term C_i is defined as follows:

$$C_i = 0.25 + (1 - p)(1/(1 + m))$$

where p = per cent of palletized cargo

m = degree of mechanization between 0 and 1

= 0 for low mechanization

= 1 for high mechanization

The factor of 1/40 in Equation (1) is used to estimate the office space requirements. The factor was derived from the assumptions that the average office worker can process an average of 25 shipments per day, that each office worker requires an average of 200 square feet (including all facilities, entrances, utility rooms, etc.) and shipments average about 300 pounds. These assumptions imply about 2 man-hours are required per ton of throughput, which are the figures for Flying Tiger in New York.

Therefore, in substituting the applicable values from the specified tables, Equation (1) would read:

$$S = 5.48 \times 25{,}000 \times 2.0 \times \left[0.75 \times \left(\frac{0.48}{6.5} + \frac{0.52}{9.5} \right) + \frac{1}{40} \right.$$

$$S = 33{,}300 \text{ square feet}$$

Equation (2) - Annual Land Rent

The values for r_L (the annual land rent/square foot) in Equation (2) were obtained from Air Cargo Policy Recommendation, Canadian Department of Transportation, for Montreal and Investment Opportunities in Air Cargo Terminal Operations, MRC, July 1969, for New York. The annual rental costs from these reports are \$0.12 per square foot for Montreal and \$0.23 per square foot for New York.

The constant of 50,000 represents the square feet required for each apron loading position and is an average of the estimates of 66,000 square feet for a taxi-in/taxi-out position and 36,000 square feet for a taxi-in/tow-out position. Multiple position aprons like UAL San Francisco average 52,000 square feet for five taxi-in (net positions) because of the overlapping of positions. The five planes cannot move simultaneously without interference but this is not an important constraint. Any plane can taxi in or out while the other planes are still. The number of apron or loading positions, A_T, for each throughput were determined with the assumption that each position could handle 4 arrivals and departures per day and that 50 tons would be handled on and off each plane. Thus, one position would suffice unless the peak daily throughput exceeds 200 tons on the freighter aircraft. We assumed that all cargo would be carried in the bellies of passenger planes at the 5,000 short ton annual throughput level, and thus no loading positions would be required; for all other throughputs, one-half of the cargo is allotted to passenger planes. Table F-2 presents the values of A_T that were used in the analysis.

Y_L is a dummy variable and assumes a value of zero when Montreal is being analyzed and a value of one when New York is being analyzed. It is used in the various equations to zero out costs not applicable to Montreal. In this case, there is no land rental for the apron assessed against the carrier.

The relative truck parking space is a function of peak day throughput, the per cent plane-to-plane ratio and the degree of palletization. Since the cargo terminal space is also a function of these parameters, the truck parking space is in some ways proportional to the cargo terminal area. A study of the layouts of various airports, most especially the Miami International Airport, showed the truck parking area is about 1.5 times the cargo terminal area for terminals that have a plane-to-plane ratio of about 25 per cent and have about 25 per cent of the cargo moved through the terminal on pallets. If the plane-to-plane ratio is 50 per cent, we assumed the truck area could be reduced to 1.25 times the cargo-handling area. We also assumed the turck area could be reduced if 25 per cent of the cargo moved through the terminal on pallets. We did not reduce the truck area correspondingly when the cargo handling area was reduced for mechanization. The M_i term in Equation (2) is the factor used to determine the truck parking area given the basic cargo terminal area (before applying the C_i term) and is defined as follows:

$$M_i = 1.5(7/6 - 2J/3)(5/4 - p)$$

where J = plane-plane ratio

p = pallet ratio

The values of M_i used in the specific cases analyzed are presented in Table F-3. The annual land rental cost in the illustrative example then becomes:

$$R = 0.12 \left| 50{,}000 \times 1 \times 0 + 33{,}300 + 5.48 \times 25{,}000 \times 2.0 \times 0.939\left(\frac{0.48}{6.5} + \frac{0.52}{9.5}\right)\right|$$

$$R = 7{,}970$$

Equation (3) - Annual Fixed Facility Costs

The annual fixed facility costs include depreciation, return on investment maintenance and repair and insurance of the terminal, apron and truck parking area. We have calculated return on investment using the discounted cash flow method and we have assumed the other annual costs can be considered as a per cent of the original investment. The annual cost per dollar of investment, N_c, is presented in Table F-4. The C_L term is the total construction costs of the terminal buildings and are presented in Figure F-1. The curves were developed from data in Dodge-Cut Calculator and Valuation Guide Ed. 4 October-December, 1971 using the base costs of truck terminal and office construction, indexed by

Table F-4

ANNUAL COSTS PER INVESTMENT DOLLAR

	Construction	Cargo Handling Equipment	Loading Position Equipment
Life (L)	20 years	10 years	6 years
Tax rate (T)	55%	55%	55%
After tax return (i)	15%	15%	15%
Capital recovery factor*	29.4%	32.1%	38.4%
Maintenance and repair	1.5%	10.0%	20.0%
Insurance and taxes**	2.5%	2.5%	2.5%
Total cost per investment dollar (N)	$N_c = 33.4\%$	$N_e = 44.6\%$	$N_L = 60.9\%$

$$* \text{ CRF} = \frac{\dfrac{i}{1 - \left(\dfrac{1}{1 + i}\right)^{L}} - \dfrac{1}{L}}{1 - T} + \frac{1}{L}$$

where i = after tax return on investment

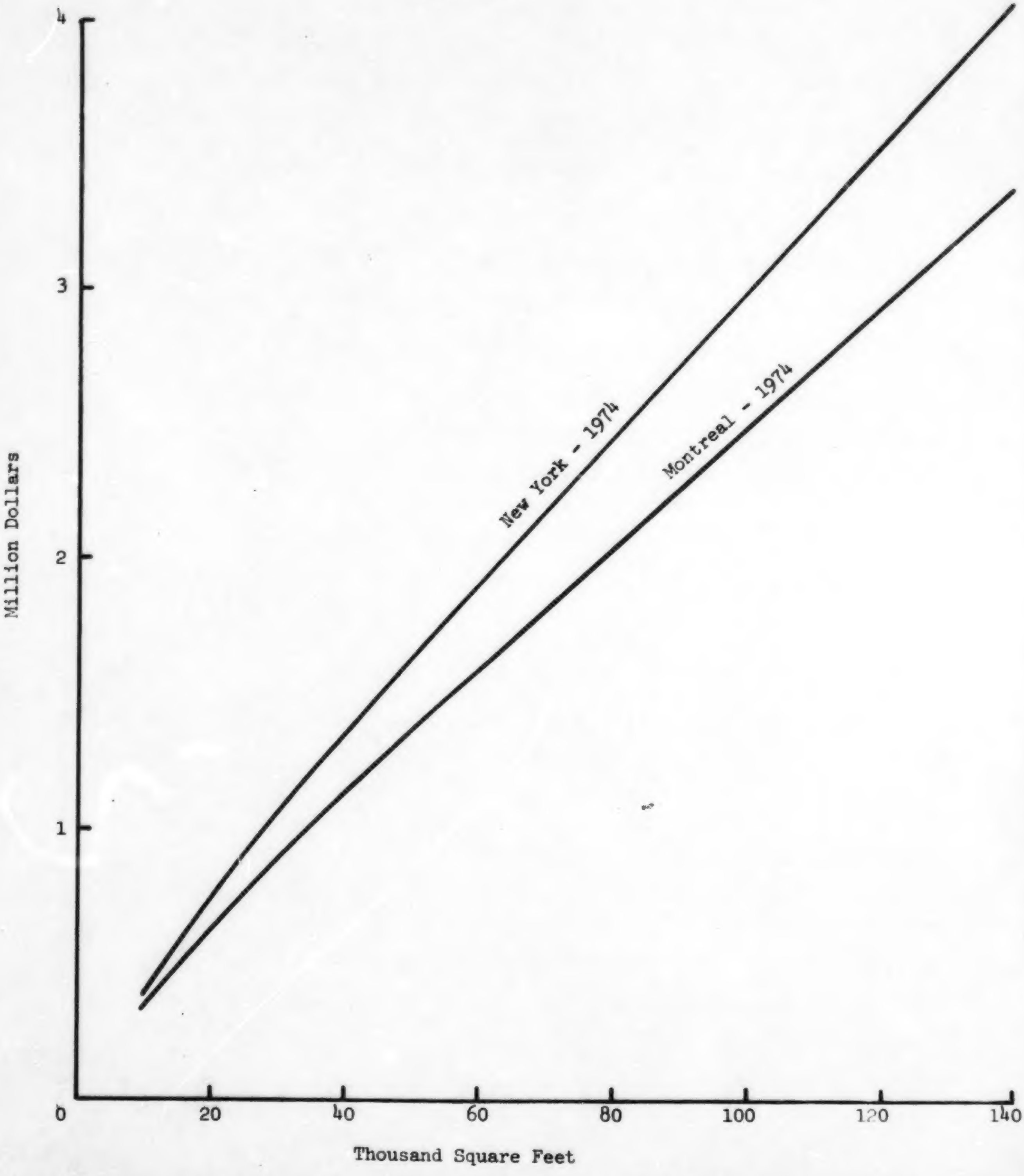
L = life in years

T = income tax rate

** Property taxes.

Figure F-1

BUILDING CONSTRUCTION COSTS
(Dollars)



locality for New York and Montreal, and inflation from 1966 to 1971 dollars. The costs were extrapolated to larger size buildings than were covered by the data.

The second term in Equation (3) is the apron investment costs. We assumed that the unit cost is a constant \$2.50 per square foot for construction of the apron area. The cost applies only to New York terminals. This constant was estimated by inflating to 1974 prices of costs estimated in the earlier MRC study of \$2.00 per square foot. This estimate is at the low end of a cost range of \$2.00 to \$4.00 suggested by the San Francisco International Airport engineering department. Of course, the cost will be a function of local soil conditions, labor, and material prices. The Air Cargo Policy study quoted a lower cost -- around \$1.00 per square foot. The truck parking paving costs (P_L) were assumed to be \$1.21 per square foot in Montreal and \$1.46 in New York and are based on data in the Dodge report.

Substituting the appropriate values in Equation (3) for the illustrative example:

$$C = 0.334 \left[968{,}000 + (1 \times 50{,}000 \times 2.50 \times 0) \right.$$

$$+ 1.21 \times 5.48 \times 25{,}000 \times 2.0 \times 0.939 \left(\frac{0.48}{6.5} + \frac{0.52}{9.5} \right)$$

$$C = \$337{,}000$$

Equation (4) - Annual Equipment Costs (\$)

The annual equipment costs are the costs of all equipment used in the terminal such as conveyers, forklifts, dollies, etc. The equation is divided into two major sections. The first pertains to equipment associated with the terminal function of sorting, palletizing, etc. The second pertains to equipment at the loading dock. The annual cost per dollar of cargo handling equipment investment, N_e, is developed in Table F-4. The T x K_T/365 term converts annual throughput into peak-day tons. E_i is the investment per peak-day ton for cargo-handling equipment and is dependent upon the degree of mechanization of the terminal. The values used in this analysis are presented in Table F-3. These values were developed on the basis of published reports of investment and capacity for several new terminals, and inflated to 1974 prices. The factor was validated by reference to the prices and to estimates of the quantity of specific handling equipment -- carts, forklifts, container dollies -- for typical unmechanized terminals.

The term E_L, is simply a conversion factor for Montreal where the installed costs of equipment would be slightly higher than New York, allowing for customs duties and lower installation labor costs. We have assumed that the overall costs would be 6 per cent higher in Montreal compared to New York. Therefore, E_L assumed a value of 1 for New York terminals and 1.06 for Montreal terminals.

The annual cost per dollar of loading position equipment, N_L, is described in Table F-4. The cost per loading position, $91,000, was developed by inflating to 1974 prices the cost for a pallet lift and two pallet transporters quoted by Cochran Western Corporation of Salinas, California. Pallet dollies or storage positions are considered as part of the terminal cargo handling equipment.

The constant 1.12 in the second part of Equation (4) accounts for the 12 per cent customs duty on imported equipment. The $(1 - Y_L)$ exponents effectively reduce the factor $1.12^{(1 - Y_L)}$ to 1.0 for New York.

Substituting the appropriate values for the illustrative example into the equation:

$$E = (0.446 \times (\frac{25,000 \times 2.0}{365}) \times 1,625 \times 1.06) + (0.609 \times 1.0 \times 91,000 \times 1.12)$$

$$E = \$167,000$$

Equation (5) - Annual Labor Cost ($)

The annual labor cost has two major components, production labor and security labor. The wage production cost per hour, W_{cL}, was determined by inflating current wage rates to 1974 rates. The resulting rates are $4.76 per man-hour in Montreal and $6.00 in New York.

The average labor productivity in man-hours per ton of throughput, H_1, was developed for each case on the basis of the percentage of tonnage requiring each type of handling and the estimated productivity for each type of handling. The present inbound ratio, the palletization ratio, the plane-plane ratio and the level of mechanization all influence productivity.

The man-hours for each type of handling was developed by allocating a portion of time for plane terminal handling, terminal/truck handling, palletization and depalletization, and documentation and control, including office functions. The allocations were then calibrated to be consistent with certain Flying Tiger terminal performance figures and with projection of mechanical terminal performance figures in a report by Robert F. Stressel, "Airfreight Terminal Techniques" from Coordinated Transportation - Problems and Requirements, Cornell Maritime Press, Inc. 1969. The resulting average productivities are presented in Table F-3.

The security guard wages per hour, W_{sL}, were derived for Montreal from an unpublished Swan Wooster study for CTC giving estimates of $7,500 per year for security guards. This estimate was inflated at 6 per cent per year to simulate 1974 costs. The New York wage was estimated by inflating Montreal costs in proportion to the production labor rates. The resulting costs are $4.29 per man-hour for Montreal and $5.41 for New York. We assumed the total security man-hours required will be as follows:

Throughput short tons	Annual Man-Hours	Approximate Number of Men
5,000	5,000	2
25,000	13,000	6
37,500	15,500	7
50,000	17,500	8
100,000	25,000	12

Substituting in Equation (5) for illustrative example:

$$U = 4.76 \times 25{,}000 \times 2.142 + 4.29 \times 25{,}000 \times 0.52$$

$$U = \$31{,}900$$

Equation (6) - Airport Tonnage Charges ($)

This equation applies to costs at Montreal only and the $(1 - Y_L)$ factor reduces the equation to zero costs for New York. These charges are a substitute for the costs at New York for apron land rent and apron construction. The constant 1.275 is the sum of charges recommended in the airport policy report. The tonnage charges for the example are:

$$D = 25,000 \times 1.275 \times 1$$

$$D = \$31,900$$

Equation (7) - Cost Per Ton ($)

Finally, to derive a cost per ton figure, substitute the appropriate values previously calculated above into Equation (7):

$$\text{Cost/Ton} = \frac{R + C + E + U + D}{T}$$

and in the illustrative example:

$$\text{Cost/Ton} = \frac{\$7,970 + \$337,000 + \$167,000 + \$311,000 + \$31,900}{25,000}$$

$$\text{Cost/Ton} = \$34.20$$

The value of $34.20 is the value appearing in Table 22 in the main body of the report.

Appendix G

DISTRIBUTION CENTER COSTS

Appendix G

DISTRIBUTION CENTER COSTS

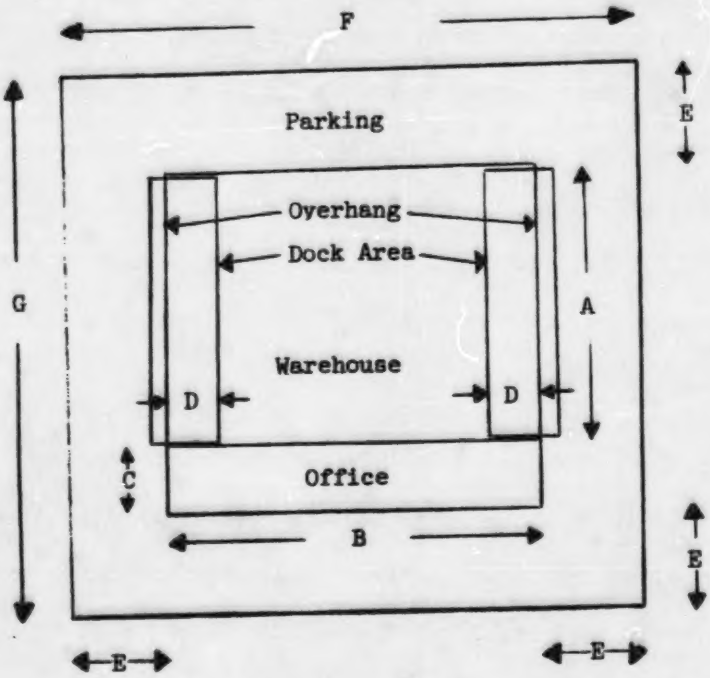
Distribution centers of three sizes -- 100,000, 200,000 and 400,000 square feet -- were laid out and costed. The three centers shall be referred to as M-1, M-2 and M-4. Throughput is taken to be in the range of 0.60-0.75 short tons per square foot. The major cost components considered were buildings, equipment and labor. The details of the computations, assumptions, data sources and summary information follow.

Buildings

The general layout of the distribution centers and the dimensions for M-1, M-2 and M-4 are shown in Figure G-1. Corresponding areas in square feet, appear in Table G-1. The buildings were assumed to be of tilt-slab construction, and to have 20-foot-high walls. There are dock areas on two sides, each 16 feet deep and entirely within the warehouse area. Trucks back up to the docks, protected by an overhang. An office area is adjacent to one and of the warehouse. The buildings are surrounded by an area for parking and access, 100 feet wide on each side. The entire site is enclosed within a chain-link fence, 8 feet high and with two 10-foot gates. There is a railroad siding and rail ramp along one side of the warehouse. Individual construction cost estimates were made for the warehouse, office space, sprinklers, heating, the dock area and dock doors, the rail ramp and its doors, the parking area and fencing. Unit costs are given in Table G-2, and component and total construction cost estimates are in Table G-3.

FIGURE G-1

DISTRIBUTION CENTER LAYOUT



Layout Dimensions, Feet

Dimension	Warehouse Area, Square Feet 100,000	200,000	400,000
A	256	320	480
B	391	625	833
C	26	24	27
D	16	16	16
E	100	100	100
F	591	825	1,033
G	482	544	707
Number of dock doors	16	20	30
Number of rail ramp doors	3	5	8

Table G-1

DISTRIBUTION CENTER AREAS

Location	Warehouse Area - Square Feet		
	100,000	200,000	400,000
Office	10,000	15,000	22,500
Docks	8,192	10,240	15,360
Parking	174,520	233,800	308,067
Entire Site	284,520	448,800	730,567
Fence Perimeter, feet	2,145	2,738	3,481

Table G-2

CONSTRUCTION UNIT COSTS

Item	Unit Cost $/sq. ft.
Warehouse	3.98
Office	
10,000 sq. ft.	18.75
15,000 sq. ft.	17.75
22,500 sq. ft.	16.75
Sprinklers	0.40
Steam Heat	0.41
Parking Area	1.47
Dock Area and Rail Ramp	3.73
Doors, Dock Area and Rail Ramp - each	$1,568
Fencing, per lineal foot	
100,000 sq. ft. warehouse	$5.36
200,000 sq. ft. warehouse	4.70
400,000 sq. ft. warehouse	4.56

Table G-3

CONSTRUCTION COSTS AND ANNUAL COSTS FOR FIXED FACILITIES
(Dollars)

Item	Warehouse Area - Square Feet		
	100,000	200,000	400,000
Construction			
Warehouse	398,000	796,000	1,592,000
Office	187,500	266,250	376,875
Sprinklers	44,000	86,000	169,000
Heating	45,100	88,150	173,225
Parking Area	256,550	343,675	452,850
Dock Area	30,550	38,200	57,300
Dock Doors	25,100	31,350	47,050
Rail Ramp and Doors	12,825	23,125	38,575
Fences	11,500	12,875	15,875
TOTAL	1,011,125	1,685,625	2,922,750
Annual Cost			
Warehouse, Office, Dock, Parking	310,345	518,812	902,074
Rail Ramp and Doors	4,032	7,271	12,128
Fences	4,108	4,599	5,671
TOTAL	318,485	530,682	919,873

We inflated any basic cost information obtained as applying in San Francisco by 17 per cent for Montreal to cover duty and transportation costs.

Information and data sources:

1) Construction costs were taken from F. W. Dodge, Building Cost Calculator and Valuation Guide, April-June, 1972.

2) San Francisco costs for fencing were obtained from Western Steel & Wire Co., in San Francisco.

Basis for computing annual costs

Annual costs for the three sizes of distribution centers are given in Table G-3. The following factors were used in the computations:

1) Values of CRF (capital recovery factor) were computed on the basis of a 15 per cent return on investment after taxes and a 50 per cent tax rate.

2) For fencing, the CRF, based on a 7-year depreciation, was 0.3372. Annual M&R (maintenance and repair) was taken at 2 per cent of initial cost.

3) For all other fixed facilities, the depreciation period was taken at 20 years, and the CRF was 0.2695. Added annual costs were 2 per cent of initial cost for M&R, and 2.5 per cent for insurance and taxes.

Equipment

Racks

We assumed that a rack would hold four pallets, and that each pallet has a capacity of 1.5 short tons; thus, 5 short tons per rack. We also assumed an annual turnover rate of 10, and that at most 75 per cent of throughput requires racks. Thus, for M-1 (60,000 short tons throughput per year) we require 9,000 racks, and proportionately for the larger installations. We used a unit cost of $56.16 per rack; on the basis of a 10-year depreciation, the CRF was 0.2985. Rack costs are summarized in Table G-4.

Information and data source: Interlake Storage Products Division of Lodi Fab Industries, Inc.

Forklift trucks

We examined the characteristics of 10 models of Clark forklift trucks, and selected three as satisfying the range of operations to be performed. All models operate in an 8-foot aisle. The electric forks operate for 8 hours on a charge. The machines are:

Model TW-30, electric. Recommended for truck operations, has pneumatic tires for dock/truck movement, will go up 15 per cent grade empty. Lift, 130"; capacity, 1.5 ST; M&R, 50¢/operating hour.

Table G-4

ANNUAL COSTS FOR STORAGE RACKS

	Warehouse		
	M-1	M-2	M-4
Throughput Short tons/year	60,000	120,000	240,000
Number of racks	9,000	18,000	36,000
Annual cost, $	15,088	30,175	60,350

Model NSP-40, electric. Recommended for order-picking, has pantograph reach (horizontal scissors). Lift, 180"; capacity, 2 ST; M&R, 40¢/operating hour.

5-Ton fork, gas, heavy duty. Lift, 138"; capacity, 5 ST; M&R, 70¢/operating hour.

Unit cost data are given in Table G-5.

Source of cost data: Lifton, Inc., local distributors for Clark Equipment.

Cost basis. Salvage value after 7 years was discounted and subtracted from unit cost to obtain intial cost. Depreciation over 7 years results in a CRF of 0.3378; M&R as given for each model; insurance and taxes were taken at 2.5 per cent of unit cost.

Number of forklifts. A work flow analysis was performed to determine the time required to handle a short ton of goods by each type of machine. Requirements were based on peak-day demand, which was taken to be 0.5 per cent of annual throughput. In summary, considering the operations performed (load/unload truck, order-picking, etc.), and the fractions of cargo requiring each, the weighted average time required for each equipment was:

TW-30: 2.5 minutes
NSP-40: 8.5 minutes

We also estimated that for M-1 and M-2, the 5-ton gas forklift would be used half-time, and full time for M-4. Further, on the basis of a 5-day

Table G-5

UNIT COSTS FOR FORK LIFT TRUCKS
(Dollars)

Model	Annual Cost	Chassis	Battery	Charger	Total
TW30	6,143	11,408	2,399	1,024	14,831
NSP40	5,638	11,349	1,697	948	13,996
5-ton gas	6,116	---	---	---	15,795*
Salvage value		(20%)	(5%)	(15%)	

* Salvage value 20%

40-hour week (2,080 hours per year) and 10 per cent down-time for maintenance, we arrive at the numbers of equipment and total annual costs shown in Table G-6.

Labor

Sources for unit labor costs

1) Labor and terminal overhead: Digest of Warehouse Cost Calculations & Handling Standards, Marketing Publications, Inc., Washington, D.C.

2) Labor rates: Obtained by Swan Wooster Engineering Co. Ltd., Vancouver, B.C., from union contracts, during course of CTC containerization study, 1970-71.

Three classes of labor were estimated. Forklift operators and sorters (other terminal labor) were estimated at $4.76 per hour, and clerks at $4.29 per hour. We took overhead at 21 per cent of direct labor; A&G, as a per cent of direct labor, varied with the size of warehouse, The value for M-1, M-2 and M-4 were 94 per cent, 90 per cent, and 84 per cent. Labor hours in each category were computed in the same way as equipment requirements, by estimating the time required for each operation, and matching times to throughput on a peak day. We estimated weighted time to process one short ton of cargo as:

Fork drivers:	11.000 minutes
Sorters:	17.25 minutes

Table G-6

ANNUAL COSTS AND COMPLEMENT OF FORKLIFTS

	Warehouse Throughputs (000 ST/yr)					
	M-1		M-2		M-4	
Number	60	75	120	150	240	300
TW30	4	5	7	8	13	14
NSP40	11	13	22	27	42	51
5-ton gas	0.5	0.5	0.5	0.5	1	1
Annual Cost ($000)						
TW30	24.5	30.7	43.0	49.1	79.9	86.0
NSP40	62.0	73.3	124.0	152.2	236.8	287.5
5 ton-gas	6.1	6.1	6.1	6.1	6.9	6.9
TOTAL	92.6	110.1	173.1	207.4	323.6	380.4

Clerks were estimated at one per TW-30 (that is, one per truck being processed) and additional clerks handling 6 orders per hour per clerk, at an average of 0.5 tons per order. On these bases, manning and annual labor costs are shown in Table G-7.

Total costs and cost per ton are summarized in Table G-8.

Table G-7

MANNING AND ANNUAL LABOR COSTS

	Warehouse Throughputs (000 ST/yr)					
	M-1		M-2		M-4	
Number	60	75	120	150	240	300
Fork drivers	15	18	30	36	57	68
Sorters	22	27	44	53	82	101
Clerks	18	22	32	40	61	76
Cost per hour, $						
Fork drivers	168	201	328	394	604	721
Sorters	246	302	481	580	869	1,071
Clerks	181	222	316	394	583	726
Total per hour	595	725	1,125	1,368	2,056	2,518
Annual cost, $000	1,236.7	1,506.3	2,340.0	2,845.4	4,276.5	5,237.4

Table G-8

TOTAL COSTS/COST PER TON
(Thousands of Dollars)

	Warehouse Throughputs (000 ST/yr)					
	M-1		M-2		M-4	
Component	60	75	120	150	240	300
Buildings and Grounds	318.5	318.5	530.7	530.7	919.9	919.9
Storage Racks	15.1	15.1	30.2	30.2	60.4	60.4
Fork Lifts	92.7	110.1	173.1	207.4	323.6	380.4
Labor	1,236.7	1,506.3	2,340.0	2,845.4	4,276.5	5,237.4
TOTAL	1,663.0	1,950.0	3,074.0	3,613.7	5,580.4	6,598.1
Cost/ST, $	27.72	26.00	25.62	24.09	23.25	21.99